Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

FEBRUARY, 1957

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ECHNOLOGY DEPT.

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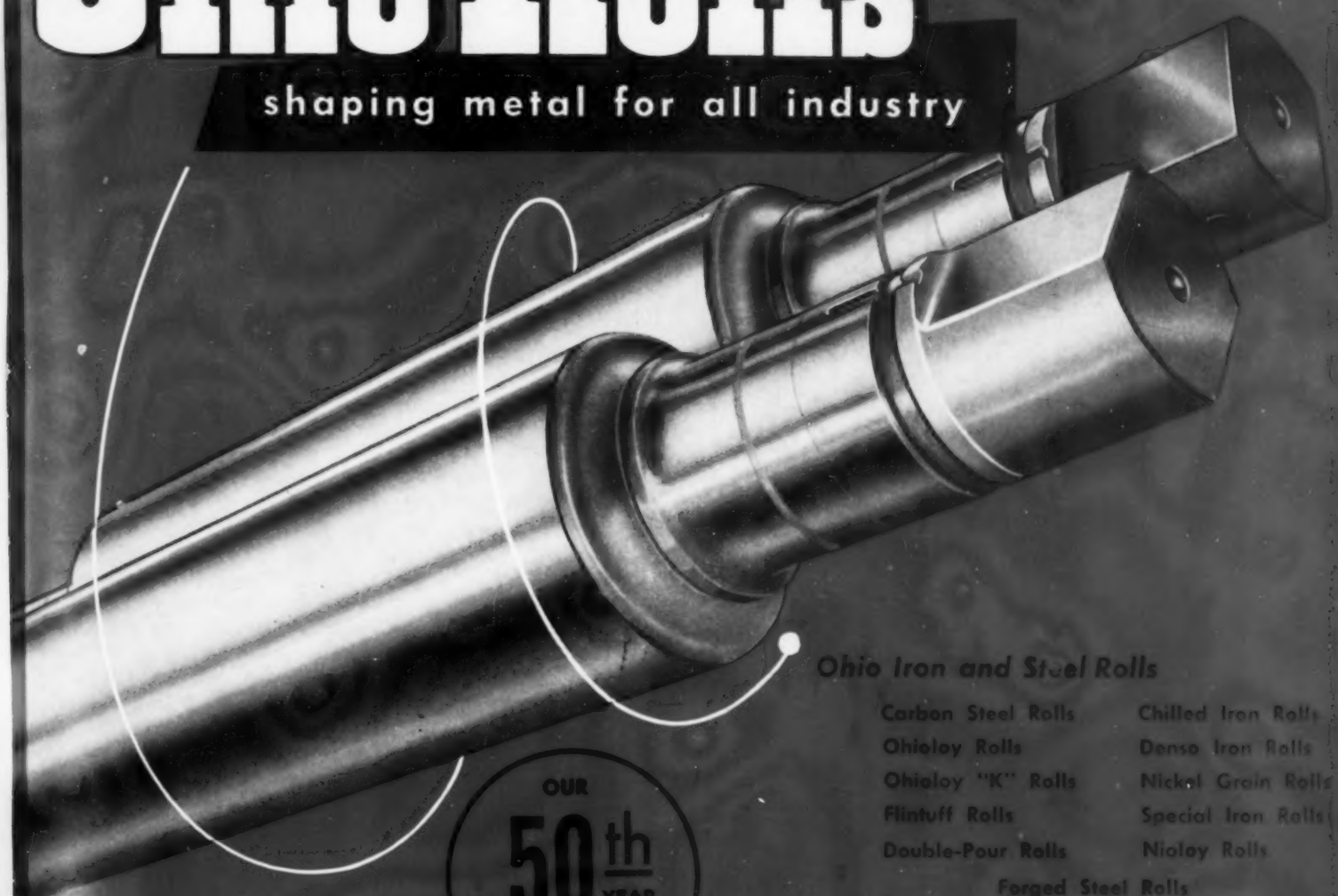
Ohio Rolls

shaping metal for all industry



Ohio Iron and Steel Rolls

Carbon Steel Rolls
Ohioloy Rolls
Ohioloy "K" Rolls
Flintuff Rolls
Double-Pour Rolls
Chilled Iron Rolls
Denso Iron Rolls
Nickel Grain Rolls
Special Iron Rolls
Nioloy Rolls
Forged Steel Rolls

OUR 50th YEAR 1907 1957

THE OHIO STEEL FOUNDRY CO.
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Plants at Lima and Springfield, Ohio

CHOICE OF THE MILL INDUSTRY...
CUTLER-HAMMER'S 505 AISE D-c BRAKE

★ Simplified Design ★ Rugged Construction ★ Dependable Performance
★ Ease of Installation and Maintenance

Compare the Cutler-Hammer 505 D-c Brake with any other, and instantly you will appreciate why the 505 is the choice of the mill industry. The service proven over-the-wheel pull rod is the simplest means of transmitting maximum braking force. Notice only one operating coil, only one torque spring, and only one torque adjustment. Gone is the clutter and multiplicity of pins, linkages and cantilevers common to other brakes.

Check the shoe-lever and base plate joints. Here troublesome pivot pins have been eliminated, and replaced by oversize bearing sockets which cut bearing pressure to a fraction of that found in other mill brakes. The tough, weather-proof capsule coil will out-perform all others. The brake shoes have heavy duty riveted linings. The wheel is specifically designed for braking service using only the finest high strength ductile iron.

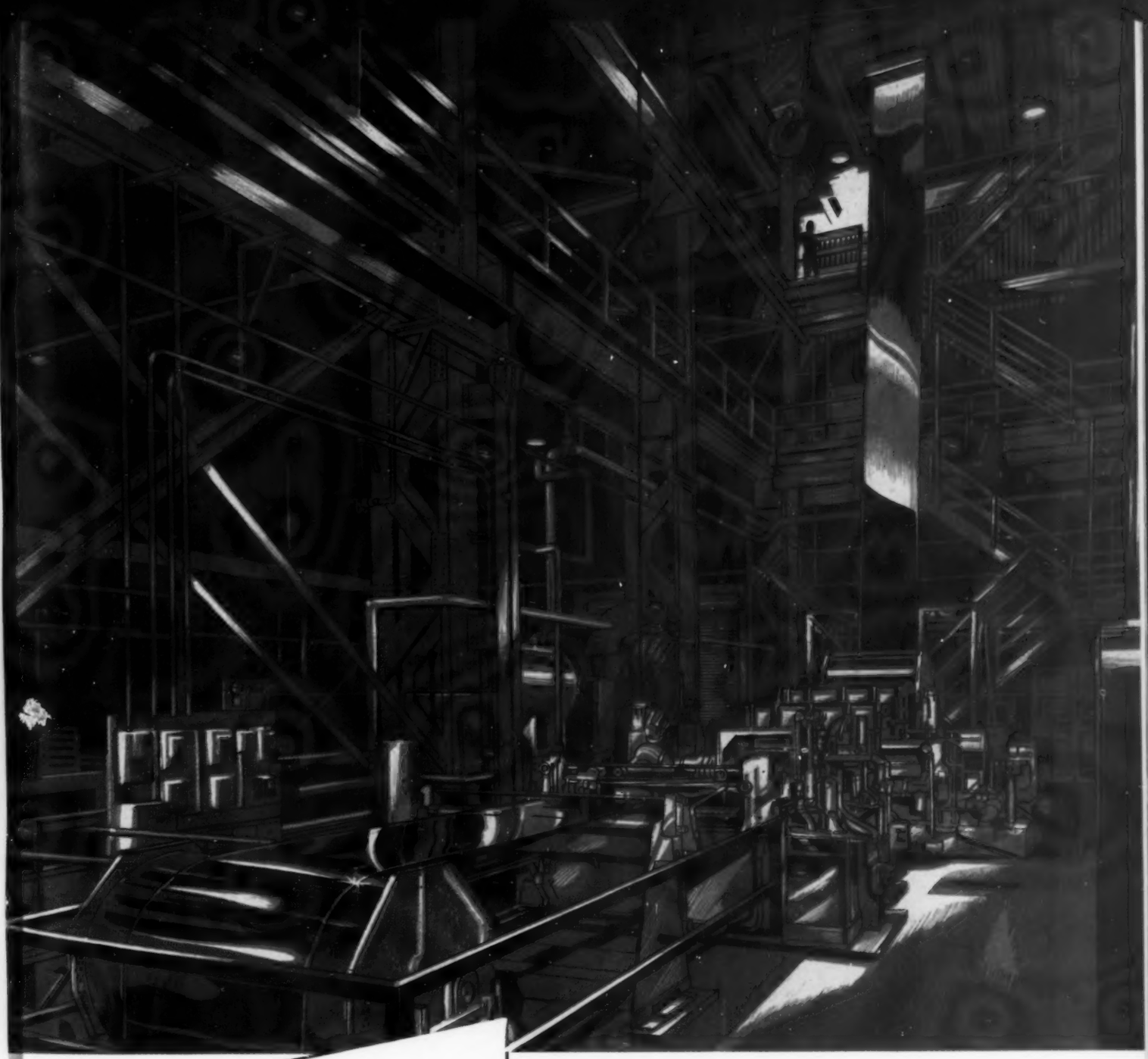
Superior performance of the Cutler-Hammer 505 D-c Brake is a natural result from its simplified design and rugged construction. The 505 is direct-acting, and exclusive one-to-one leverage provides maximum braking effectiveness. This brake was designed and built to out-perform, out-last all others.

Ease of installation and maintenance is a major consideration in any device destined for mill application. Because of the simplified design and minimum number of parts, the 505 can be completely assembled in a matter of minutes with ordinary hand tools. Capsule coil can be quickly changed or reversed while on the job. Only two adjustments required to put the brake into operation. Brake linings can be serviced quickly without disassembly of the brake. No special tools required for any maintenance operation.

CUTLER-HAMMER
MOTOR CONTROL
C-H

For complete information write for the descriptive literature detailing construction, torque ratings, types, sizes and service characteristics. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin. Associate: Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers at 20th and Northampton Sts., Easton, Pa. Editorial and advertising offices, 1010 Empire Bldg., Pittsburgh 22, Pa. Entered as second class matter at Pittsburgh, Pa., and application for re-entry as second class matter at Easton, Pa., pending.



New Ideas IN EQUIPMENT FOR CONTINUOUS COATING LINES

• New ideas recently developed by Aetna-Standard make Continuous Coating Lines more efficient. One idea focuses on a new approach for **Loop Cars.** The use of Loop Cars eliminates deep loop pit excavation and keeps strip in full view for easier inspection.

New Aetna ideas contribute to an even better finished product. Space saving in the installation results in lower first cost. There is less equipment to buy and to install.

Aetna-Standard has installed more Continuous Galvanizing Lines than all other manufacturers combined.

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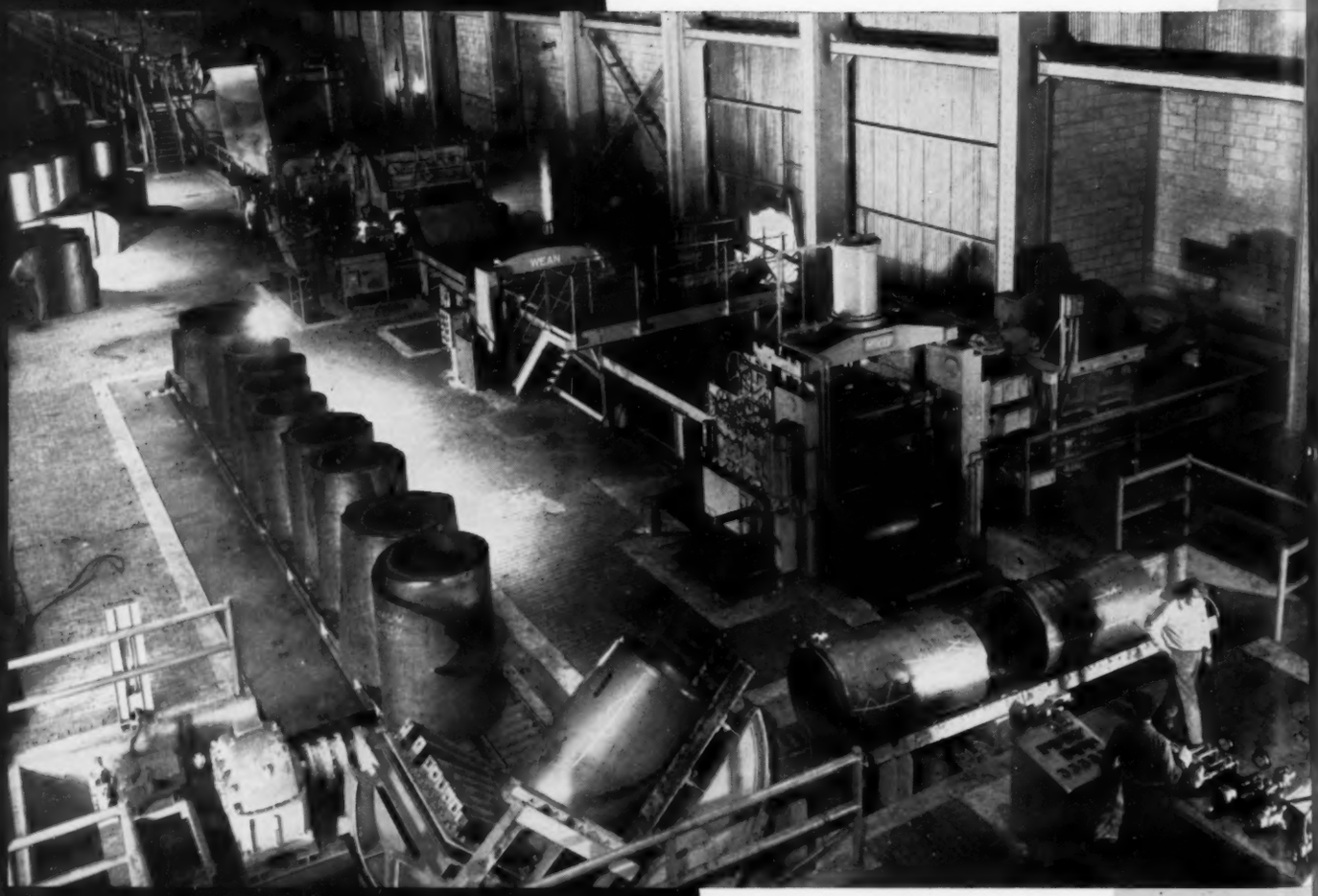
HOW WEAN CREATIVE

ENGINEERING

improves continuous Strip Pickling



FASTER, more uniform pickling at reduced costs — that's why leading steel producers prefer Wean Continuous Strip Pickling Lines. From the McKay Processing Uncoiler to recoiling, the Wean line is engineered to deliver highest quality at greatest speed.

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WEAN

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Iron AND Steel ENGINEER

FEBRUARY, 1957 VOLUME XXXIV NUMBER II

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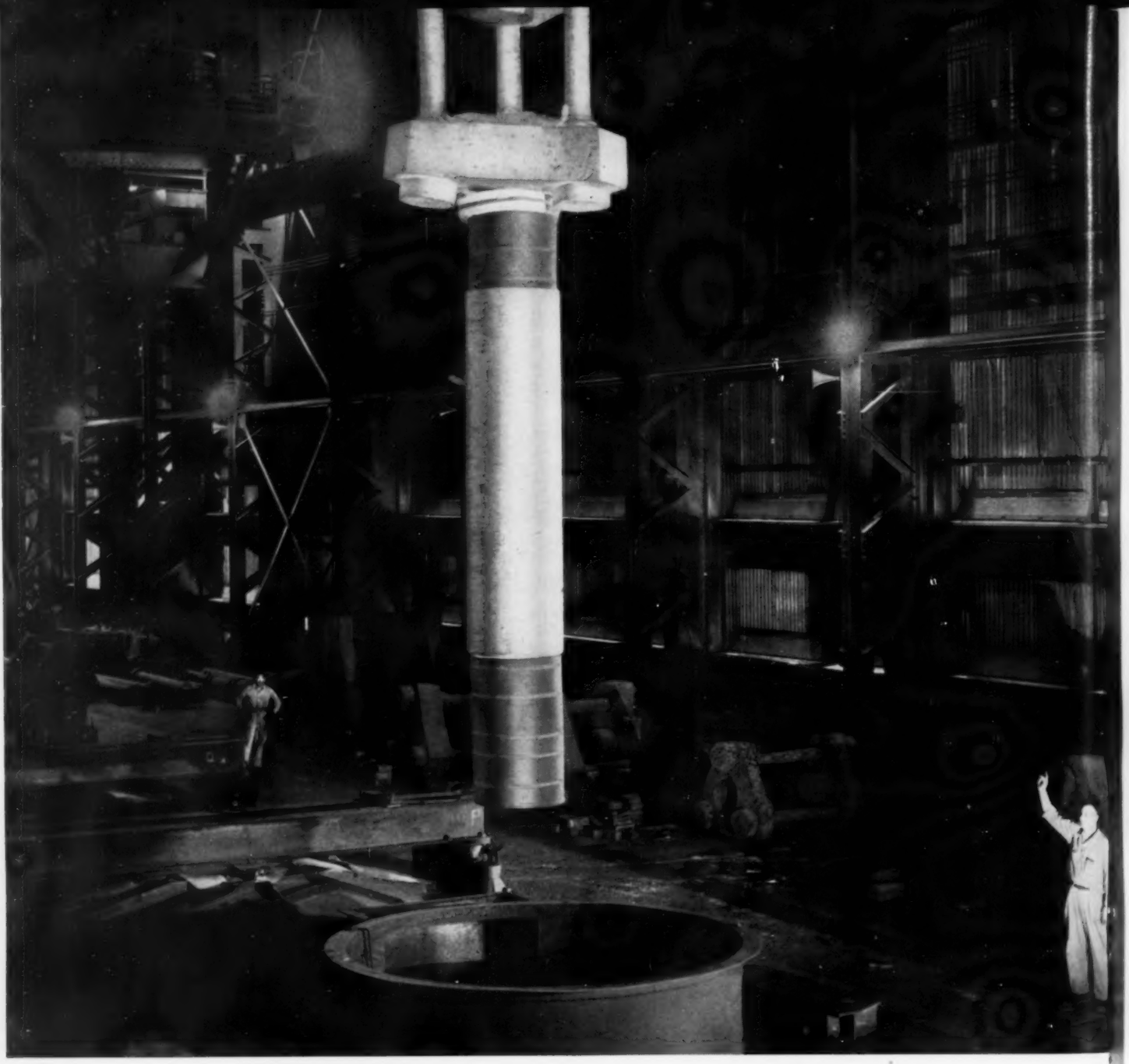

12-Ton Roll Poised for a Bath

A moment after this photograph was taken, the big heated forging was lowered into the quenching tank. Temperature of the forging and period of immersion were of course closely controlled; the forging was a steel roll in the making, and every operation had to be handled with the utmost precision.

When finished and shipped from the Bethlehem plant, the roll weighed an even 12 tons. Its overall length was approximately 17 ft; body diameter was 28 in. The purchaser ordered it to his own specifications for use in rolling aluminum.

Rolls like this require the most painstaking care, and at Bethlehem they get it. The strictest metallurgical controls are enforced at every step, beginning with the making of the steel. When a roll leaves our shops, it meets all specifications on size, finish, hardness, down to the last detail.

Bethlehem forged rolls are completely dependable for cold-rolling ferrous sheets and strip; running-down and finishing operations on copper and brass sheets; hot- and cold-rolling aluminum sheets; cold-rolling aluminum foil. Call us when we can be of service; our engineers will gladly cooperate.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

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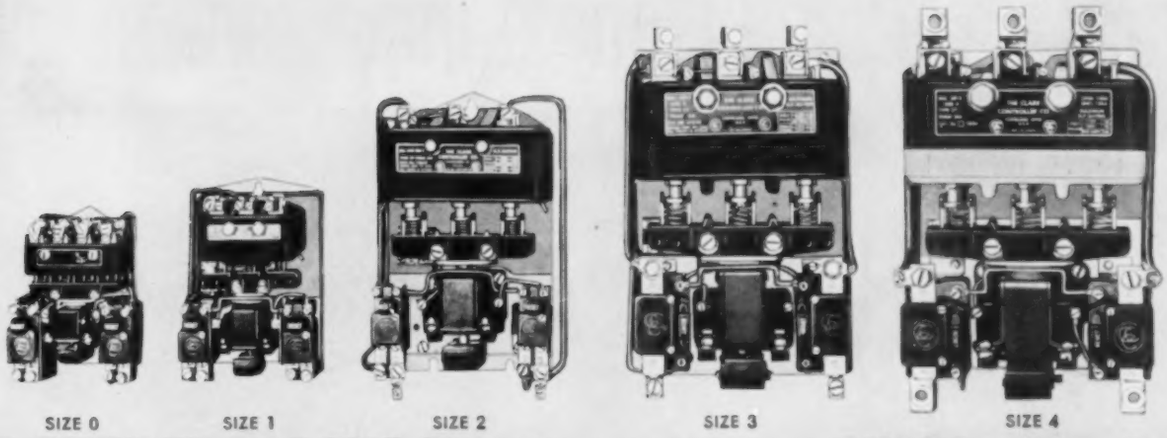
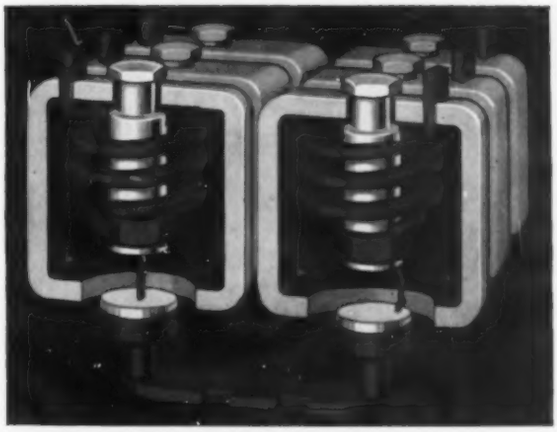


CLARK Type "CY" Starters now available in sizes

0 to 4

With the addition of the new size 4, the famous CLARK line of Type "CY" Magnetic Motor Starters now comprises the full range from 0 to 4. This means that Clark starters of the proven "CY" design incorporating vertical lift magnets are now available for more than 95% of industry's AC requirements. For installations requiring sizes 5 and larger, Clark will continue to supply dependable clapper-type starters.

Clark Type "CY" starters have many outstanding design features for more dependable operation, less maintenance and longer life. For example—rugged construction with twin-break contacts means more trouble-free service . . . contacts can be inspected without tools . . . movable and stationary contacts can be removed and replaced quickly, coils changed and the entire magnet assembly removed—all from the front—without special tools and without removing the starter from the cabinet or panel.



Revolutionary arc-quenching principle is an exclusive feature of all Clark Type "CY" starters sizes 2 and larger. It combines twin-break contacts with strong multi-turn magnetic blowouts which force the arc to rotate—alternately lengthened and confined—so that it moves continuously from a hot to a cold spot on the contact surfaces. This practically eliminates metal build-up or pitting and greatly increases contact life.

For complete information contact your nearest Clark sales office or Clark distributor, or write us direct.

The CLARK CONTROLLER *Company*

Everything Under Control

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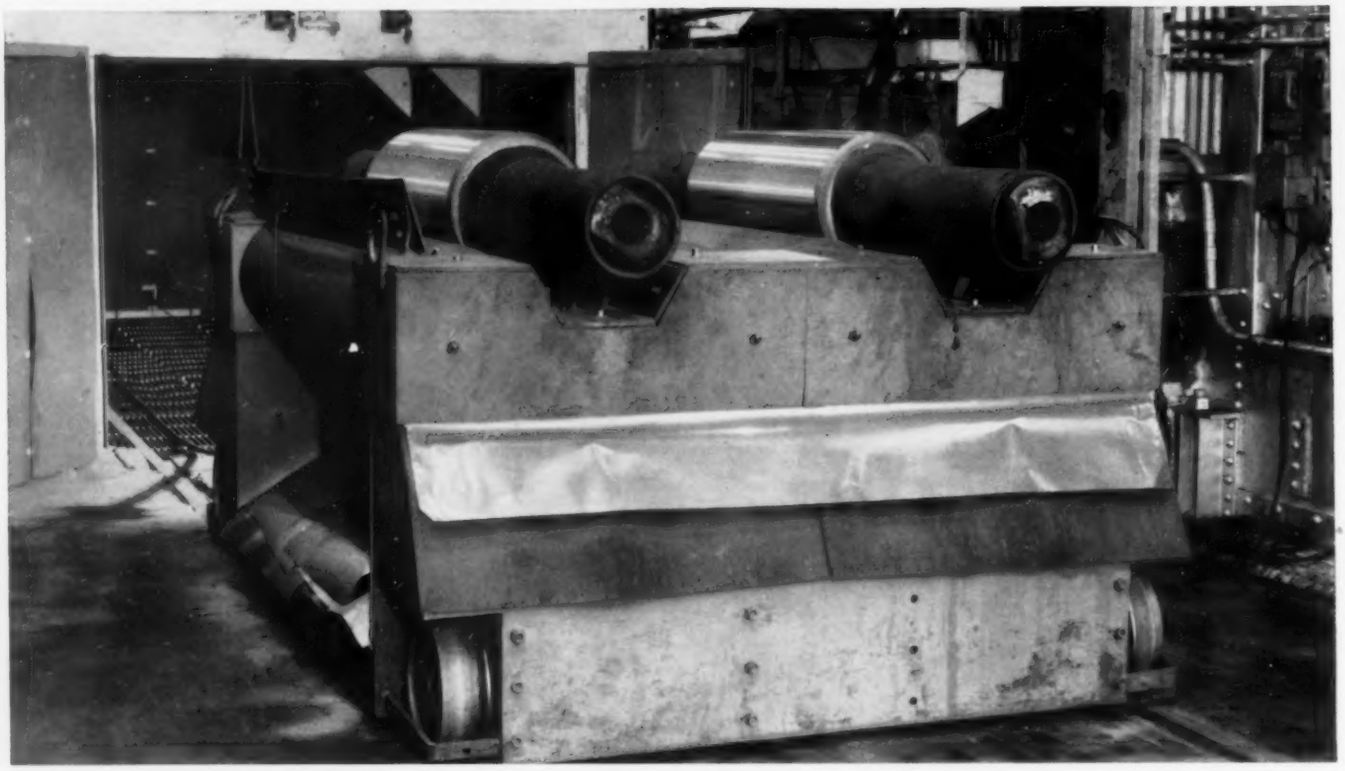
Which advantage is most important to you?



You get them all in WHEELABRATOR® mechanical mill roll etching

? Uniform etch

? Longer roll life

? Better product finish

? Time savings

? Cost reductions

The mechanical and automatic nature of Wheelabrator mill roll etching brings you all of these advantages. For instance, it eliminates the opportunity for human error. Once calibrated, it automatically produces a uniform etch, with optimum penetration, roll after roll. This also means longer roll life — as much as 30% more service life. There are no areas of shallow etch to cause too-frequent dressing and no areas of too-deep etch to cause waste of roll surface in successive etchings. This uniformity also provides more uniform surface finishes on the final product.

Variety in type and size of abrasive, velocity and volume of abrasive, speed of work travel and rotation and other variables are easily adjusted to provide close control of the surface etch. This means a single machine can produce a wide variety of finishes, each meeting a precise surface roughness specification. Time and cost savings come from speed of etching, which recently has been improved by a work car that carries two rolls at once. This not only saves etching time but also reduces mill delay. In addition, changeover for different finishes is faster and re-roll tonnage is reduced because a flatter strip is produced under increased screw-down pressures.

Why not get all of these advantages in your plant for swift, sure mill roll etching?

WHEELABRATOR®
CORPORATION

396 South Byrkit Street Mishawaka, Indiana

WRITE FOR details on the many new improvements in the Wheelabrator method of etching.

FREE

New Refractories Handbook

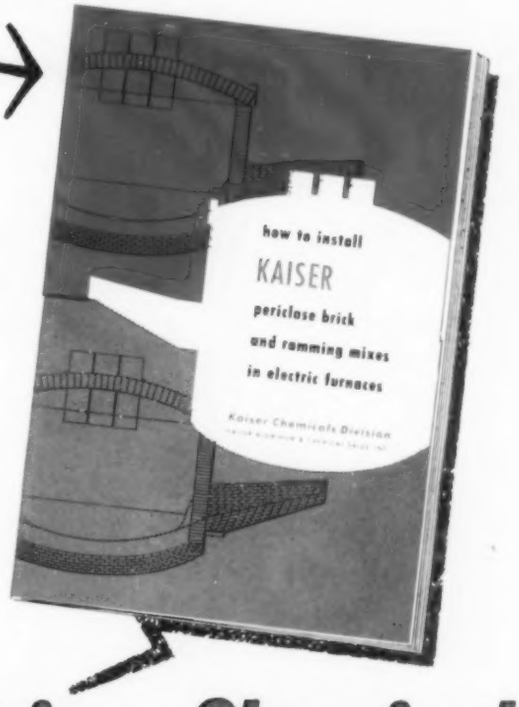
written especially for electric furnace operators

This new booklet is the most important "how to" handbook on refractories installation methods ever written for electric steel-making furnace operators.

Many of the suggestions and recommendations in this 48-page booklet have come from our customers, who cooperated in joint studies of basic brick and ramming mixes in their electric steel furnaces.

All of the recommendations are designed to help you get the greatest savings and the best possible service from proper installations of refractory brick and furnace grains.

this "How To" handbook shows you...



- Methods for installing basic brick
- Sub-hearth construction
- Side wall construction
- Lining around doorway
- Lining pouring spouts
- Roof seal
- Methods for installing ramming mix
- Hearth contour
- Tap hole construction
- Ramming bottoms
- Mixing methods
- Ramming small furnaces
- Ramming large furnaces
- Forms for ramming
- Furnace lining repairs
- Rebuild suggestions
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Kaiser Chemicals

pioneers in modern basic refractories

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We suggest that you order enough copies of this booklet for every member of your organization concerned with improved operation of your electric steel furnaces.

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Please send_____copies of your free booklet entitled "How to Install Kaiser Periclase Brick and Ramming Mixes in Electric Furnaces."

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You Get MORE

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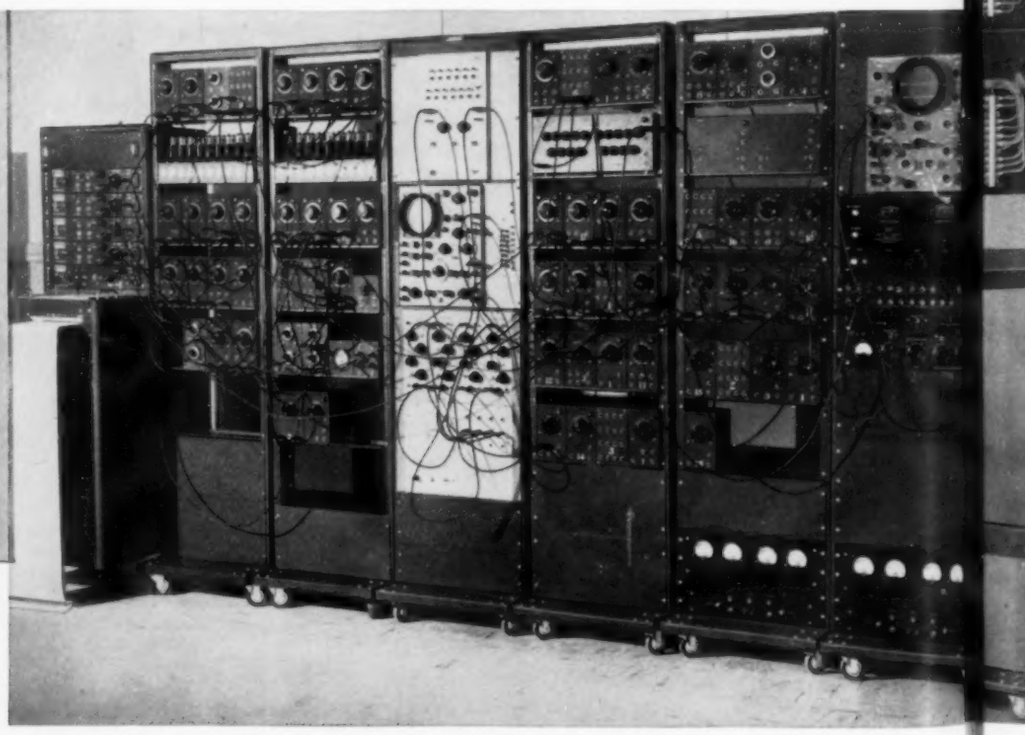
EFFECTIVE regulation is more than a matter of good regulator design. It embraces overall *system* design... the integration of interdependent components — generators, exciters, motors, regulators and other control equipment. As manufacturers of a most diversified line of electrical generation, distribution and utilization equipment, Allis-Chalmers, of course, is in a unique position to provide this practical approach to mill regulation.

Allis-Chalmers maintains separate departments, staffed by research, design, manufacturing and application specialists for each product. "Coordineering" results from an interdepartment exchange of ideas and technical information correlated in *one* department specializing in metal producing industry application. In this department, components are matched to meet the requirements of your job. Responsibility for *system* performance rests with one company.

Analytical Facilities Utilized...

System performance is simulated in the computers to get optimum configuration of components. Time constants and exciter ceilings necessary for desired response are established.



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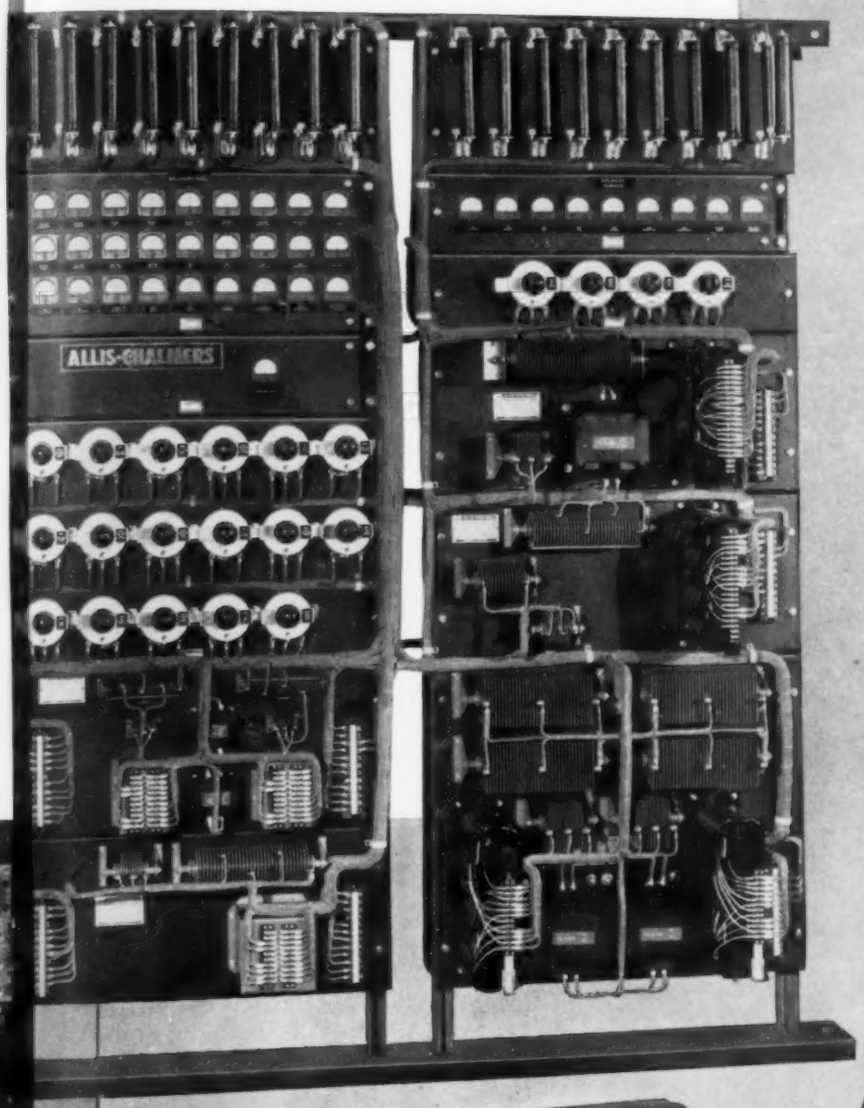


Magnetic Amplifiers

For MILL CONTROL

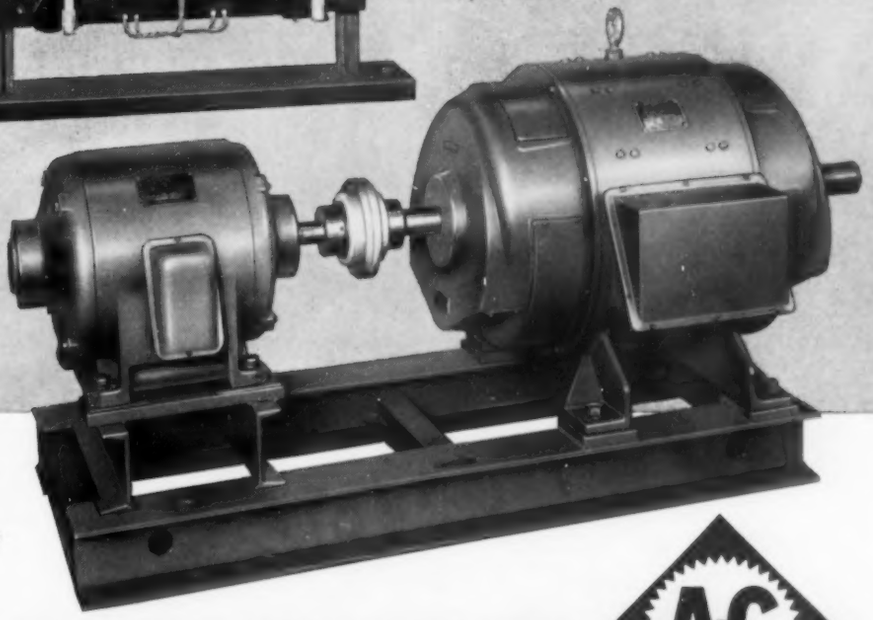
Three Types Available

1 ***REGULEX* Rotating Amplifier** — Applicable where high power levels for reversible output are desired.

2 **Magnetic Amplifiers** — Applicable where low power levels for reversing or high power levels for non-reversing are desired.

3 **Combinations of Rotating and Magnetic Amplifiers** — Each complements the other for maximum regulating efficiency.

Get all the facts. See your Allis-Chalmers representative or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.



Regulex Rotating Amplifier

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5030

15 ton, 40'-0" span Cleveland scarfing gantry operating underneath one of two 40 ton, 90'-0" span overhead traveling Cleveland Cranes in the Slab Conditioning Department. The overhead cranes haul the heavy slabs to and from the scarfing bed area.

SCARFING GANTRY with RAM-TYPE HOIST

OF INTEREST to mill men is the Cleveland single-leg scarfing gantry crane in the Conditioning Department of the Pittsburgh Steel Co., Allenport, Pa. This has a ram-type hoist which eliminates the usual swinging of loads of conventional cable or rope-type hoists. Equipped with two magnets on the ram, the gantry crane handles the heavy slabs in the area it serves and turns them over from one side to the other, enabling the scarfers to clean and prepare them quickly, ready for rolling.

The crane is unusual in that no line shafting or other mechanical connections between the bridge drives at both ends of the crane is employed. Each end truck is individually motor driven. This method of driving the bridge eliminates many bearings and considerable gearing and is an important factor in reducing maintenance to a minimum.

CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

THE American Iron and Steel Institute reports that the industry will spend a record $1,700,000,000 in 1957 for expansion and rehabilitation. This is 42 per cent above the 1956 expenditures and, coupled with something more than $1,000,000,000 for maintenance, represents a tidy market.

The Institute says that heavy expenditures will continue for years to come, with the principal problem that of finding funds to finance stay-even requirements and expansion.

▲

AN American Management Association survey shows compensation of top corporate executives rose 5.9 per cent last year, identical with factory workers.

Guess things are looking up.

▲

THE white collar man had his day back in 1846. An old history of southern Ohio lists pay for ironworker as $27 a month for the furnace keeper, $30 for a blacksmith, $21 for a mule driver, $10 to $27 a month for laborers, and $800 a year for the bookkeeper. The foundryman also drew $800 a year.

ITS interesting to note that the company store's records show beef at 3 cents a pound, pork at 8 cents a pound, tea at $1.00 a pound, house rent at $2.00 a month, men's boots $3.75 a pair and a tin bucket at 81 cents.

▲

WE made a survey of our own and find that salaried men in general think their salary checks are O.K. All they ask is that they come oftener.

▲

THE steel industry's new annual capacities: 72,970,980 tons of coke, 86,817,950 tons of iron and 133,459,150 tons of steel. Now all we have to do is keep that capacity busy. Right now a lot of the more optimistic forecasters are revising their predictions for 1957, but still point out—quite rightly—that it will still be a good year.

▲

WE recently read a prediction that, by 1975, the United States will have free, compulsory college education and high schools will be open twelve months a year.

'Spose they'll teach spelling?

A YEAR-END report of the U.S. Bureau of Mines gives the value of the mineral production of the United States at a new high of $17,300,000,000 in 1956. This figure was made up of $11,805,000,000 in fuels, $3,292,000,000 in other non-metallic minerals and $2,239,000,000 in metals.

▲

REMEMBER when they used to say "A fool and his money are soon parted?"

Now it happens to everybody. In fact, a new meaning has been given to jumping jack.

▲

CARNEGIE Institute of Technology, with 328 students scheduled to receive bachelor's degrees in June, has already scheduled interviews for some 400 business concerns.

Someone is going away empty handed—and starting salaries for engineers are expected to average about $460 a month.

▲

OF the 23,000,000-ton expansion in annual steelmaking capacity planned in Russia over the next several years, half is to come from new plants and half from the use of oxygen, improved production methods, etc.

▲

THE chap next door says middle age is when you can do just as much as ever, but don't.

▲

NET worth of some union Treasuries makes interesting reading:

	1946	1956
Steel workers	$ 4,834,964	$21,359,502
Electrical workers	7,845,301	52,253,427
Teamsters	17,369,520	36,008,446
Auto workers	715,375	39,405,361
Ladies' garment workers	38,086,540	68,435,676

Isn't it terrible the way unions have been enslaved by the Taft-Hartley Act?

▲

ACCORDING to the U. S. Bureau of Mines, marketed production of natural gas in the United States totaled 9405 billion cubic feet in 1955. Of this, 3939 billion cubic feet went to industry, with 297 billion cubic feet going to the steel industry.

▲

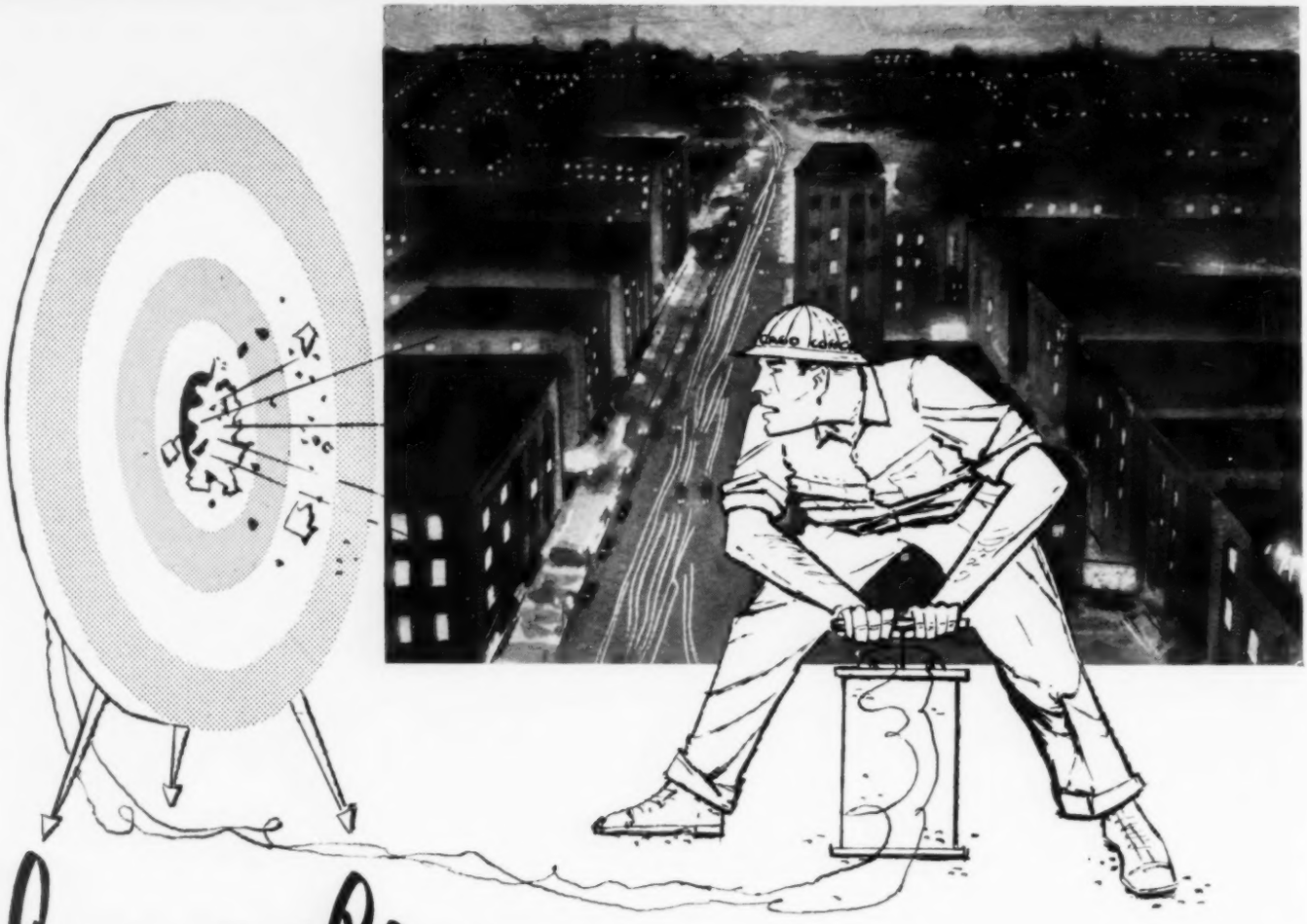
THE industrial furnace industry received orders in 1956 totaling $108,247,000 from domestic customers, $5,665,000 from foreign buyers—the best peacetime year for the industry.

▲

WE'RE inclined to agree with this definition: Golf is just a lot of walking, broken up by disappointment and bad arithmetic.

▲

A LOT of the Hungariarn refugees are trained in technical skills and mechanical trades, and are being snapped up by U. S. industries.



Controlled Blasting SAFE-GUARDS "light" FOR AN ENTIRE CITY

With better than an 80% increase in the consumption of electric power, the far-sighted engineers of a large mid-western electric power and light company decided that an addition to their main generator building was necessary. To do so meant first removing a 24" thick wall that measured 210' long by 31' high. Removing this wall in the formerly-conventional methods would not only have taken too long, but would have cost a great deal.

At this point CHICAGO CONCRETE BREAKING COMPANY'S demolition experts were called in. The question put to them: "Could dynamite be used safely on a wall that was less than five feet from operating equipment . . . equipment that meant power and light for an entire city?" The answer: CHICAGO CONCRETE BREAKING not only could guarantee to do the job of removing that wall, but would do so without disturbing the operation of that vital equipment.

In less than three weeks over 12,600 cubic feet of concrete wall was control-blasted out. A tremendous savings in time and at a cost that was but one-third of what the "old" methods would have been . . . with absolute safety to both men and equipment . . . such were the dividends that CHICAGO CONCRETE BREAKING returned to those modern-minded engineers.

If you have any rehabilitation work coming up — regardless of how complex or "tricky" it appears, phone or write today. Our 35 years of experience, know-how and ability are at your command to handle your demolition work while safeguarding your vital equipment . . . as we did in the above situation.

CHICAGO CONCRETE BREAKING CO.

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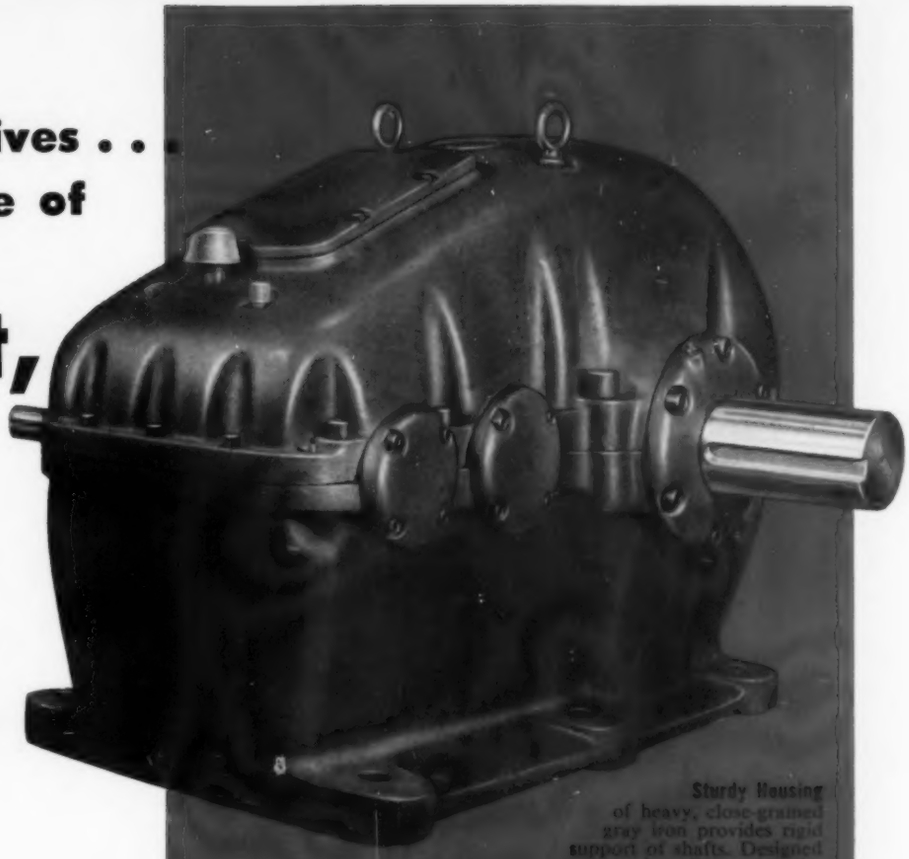
In heavy-duty drives . . . demand assurance of

permanent, accurate shaft alignment

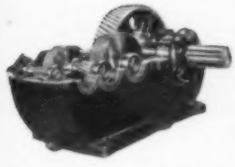


Sturdy Housing of heavy, close-grained gray iron provides rigid support of shafts. Designed so that all parts can be removed without disturbing base or draining oil.

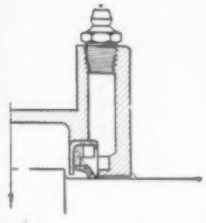
It's yours... with these other "plus" performance features — in LINK-BELT Parallel Shaft Drives

Under the shocks and overloads that are often imposed upon parallel shaft gear drives, rugged housing construction is compulsory if shaft alignment is to be maintained. That's why Link-Belt adds special reinforcement at points of greatest stress . . . has developed this design expressly for endurance in heavy-duty service.

Write for Book 2619 on this broad line with ratios to more than 300:1. Or get first-hand facts from your nearest Link-Belt office or authorized stock-carrying distributor.



Ball and Roller Bearings are of ample size and capacity to withstand shock and overloading.



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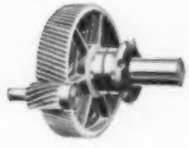

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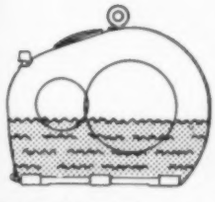

Automatic Splash Lubrication reliably supplies oil to all gears and bearings.

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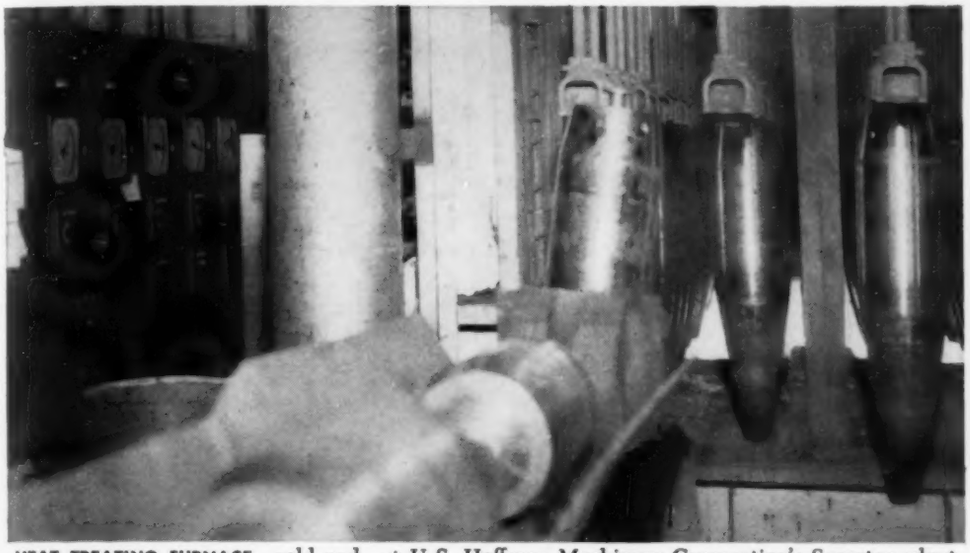
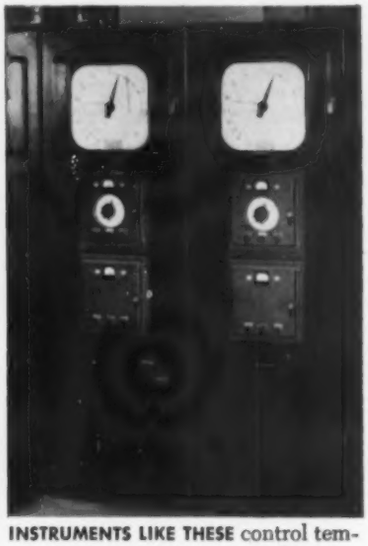


HEAT TREATING FURNACE—cold end—at U.S. Hoffman Machinery Corporation's Scranton plant. Heat treatment of projectiles, seen entering furnace at right, is automatically controlled by instruments at left.



INSTRUMENTS LIKE THESE control temperatures in rotary Hagan furnaces at U.S. Hoffman Machinery Corporation's plant. One of six installations.

World's largest hot-forge shell plant gets Bristol control

Continuous heat control is a must in the manufacture of high-explosive shells for the U.S. Army Ordnance Corps.

That's why you find Bristol Electronic Dynamaster* Pyrometer Controls at U.S. Hoffman Machinery Corporation's Scranton, Pa. plant—the world's largest hot-forge shell installation.

Rotary furnaces, built by George J. Hagan Co., heat the steel billets. Bristol control systems, using round-chart Bristol Dynamaster Pyrometers, continuously monitor and regulate the heat in three zones in each of these furnaces.

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Bristol Series 536 Free-Vane* Electronic Pyrometers automatically cut off the oil in case of furnace overheating.

Bristol Pyrometers provide precise temperature control for any industrial heating installation. You'll find complete specifications and prices in Bulletin P1260. Write for your copy today. The Bristol Company, 123 Bristol Road, Waterbury 20, Connecticut. 6.64

**T. M. Reg. U. S. Pat. Off.*

Here are the basic elements for finer temperature control. Hundreds of variations available.

1. Bristol Round-Chart Dynamaster Electronic Pyrometers.

2. Control relay.

3. Motor operator—for proportional positioning of final control units, such as valves, burners, rheostats.

There's a Bristol Controller for every furnace and oven.

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Another large tonnage steel producer looks to single stack furnaces for better annealing

"Highly pleased," say operators of pilot installation of 6 Lee Wilson furnaces

The swing to Single Stack furnaces for big coil annealing is gathering momentum with each new order placed by leading steel producers.

A large Eastern mill was the latest to break a long standard multiple-stack precedent by purchasing a pilot installation of Lee Wilson Single Stack furnaces for purposes of comparative testing.

Early results indicate that the Single Stacks easily outproduce the older style furnaces per base and per man. What's more, the quality of the steel has never been better. "Highly pleased," say operators of the pilot installation.

If you don't already have the facts on this modern method of annealing, let Lee Wilson engineers put you in touch with those who have operated both types.

Lee Wilson*
ENGINEERING COMPANY, INC.
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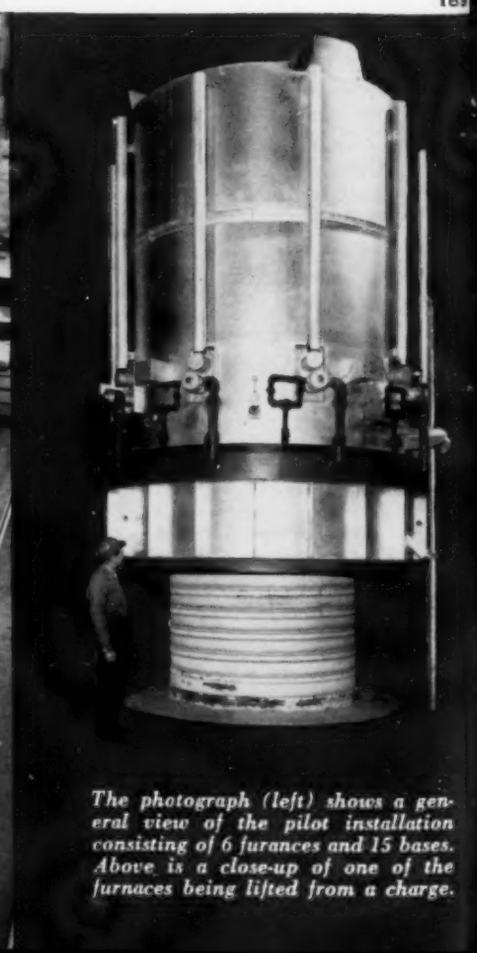
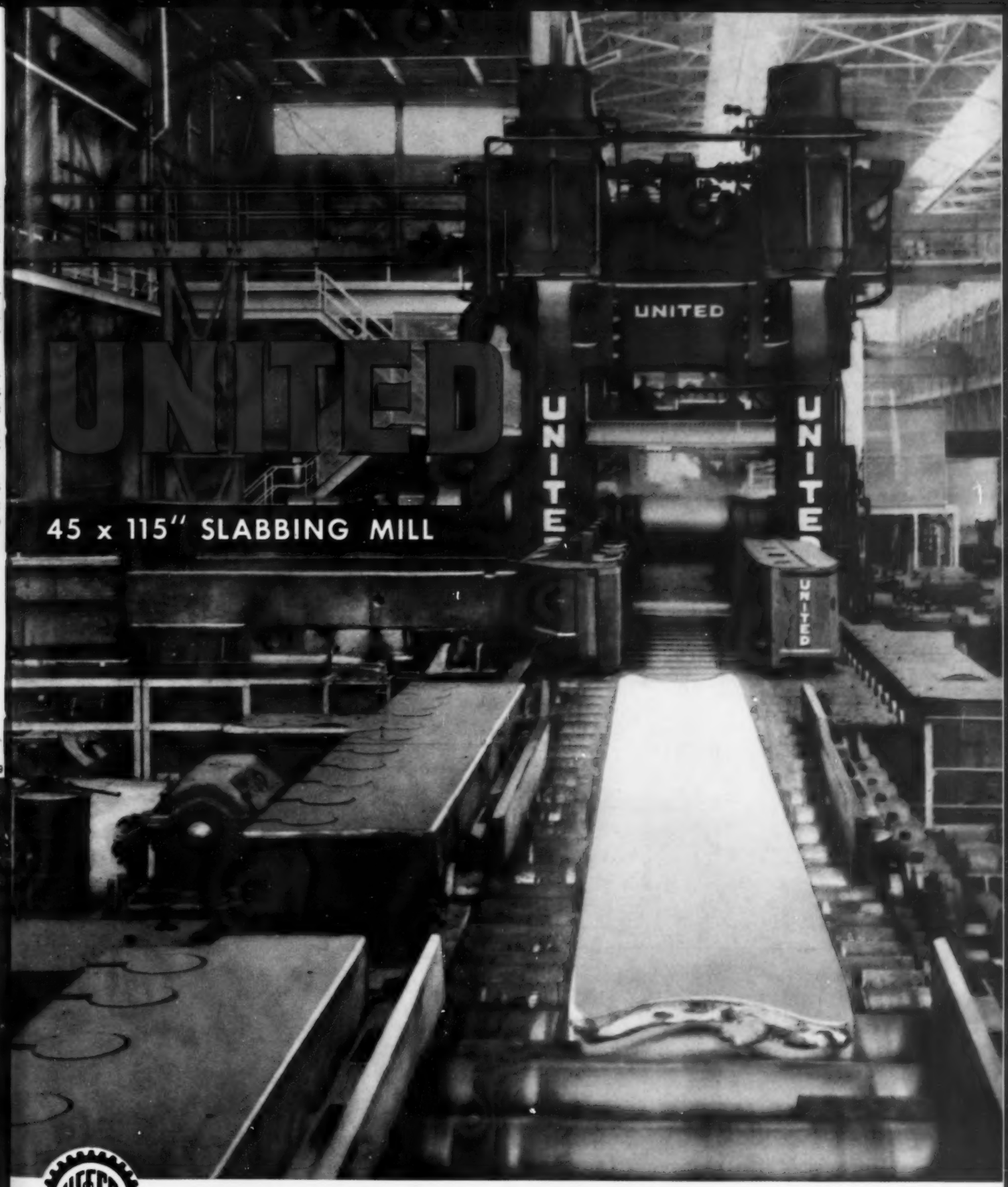
* ORIGINATORS AND LEADING PRODUCERS OF SINGLE STACK RADIANT TUBE FURNACES

189



The photograph (left) shows a general view of the pilot installation consisting of 6 furances and 15 bases. Above is a close-up of one of the furnaces being lifted from a charge.



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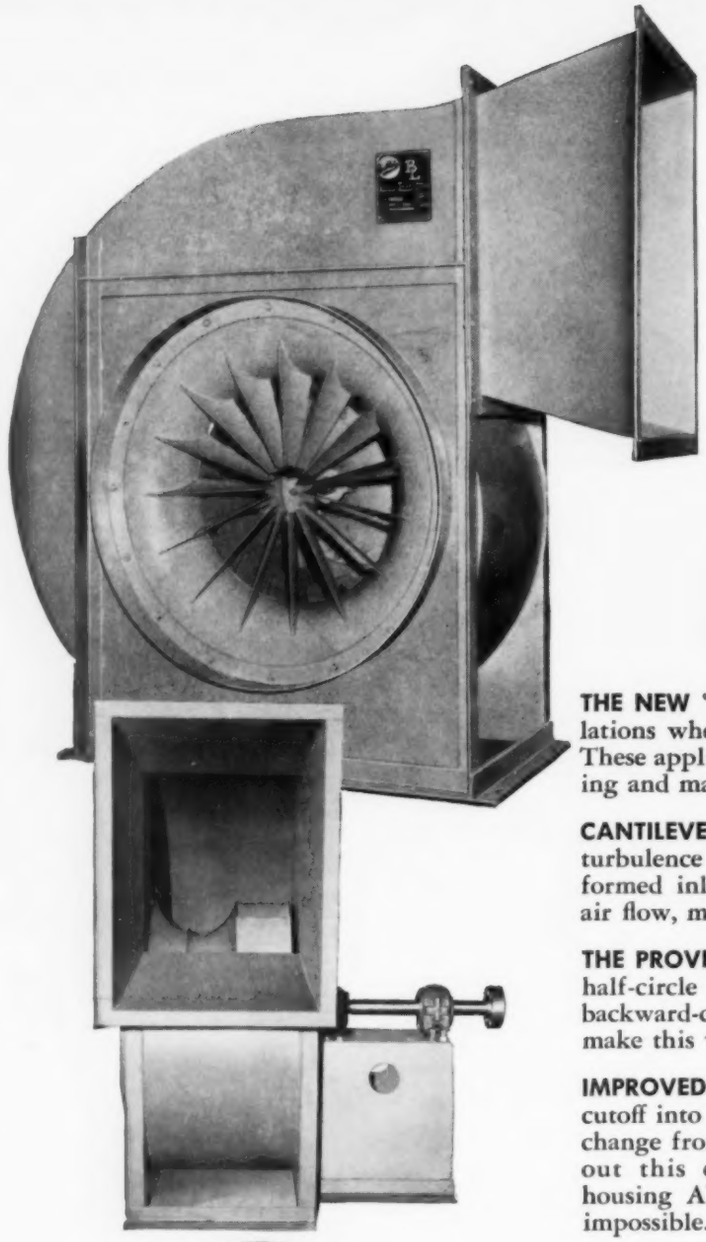

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FOR CLASS II THRU IV VENTILATING-INDUSTRIAL & MECHANICAL DRAFT SERVICE

THE NEW "Buffalo" Type "BLH" FAN is engineered for installations where total pressure requirements of 3¾" and up exist. These applications include mechanical draft, conduit air conditioning and many industrial applications.

CANTILEVERED INLET VANES eliminate center ring, reducing turbulence and improving air flow through the inlet. The die-formed inlet vanes and inlet bell further contribute to smooth air flow, minimizing effects of unfavorable inlet conditions.

THE PROVEN BL WHEEL has a deep drawn flange to form a true half-circle with the inlet cone. Highly efficient non-overloading backward-curved blades, solid back plate and extra heavy hub make this wheel ideally suited to this service.

IMPROVED FAN OUTLET — reduces outlet air turbulence from fan cutoff into duct by making more even, gradual change from velocity to static pressure. Without this complete streamlining of inlet, housing AND outlet, such high efficiency is impossible.

Smooth Divergent Flow

86% MECHANICAL EFFICIENCY — made possible by a combination of inlet, wheel and housing design. The smoothest "air-ride" in fan history.

"Buffalo" "Q" FACTOR* CONSTRUCTION gives you many years of trouble-free service. Housing is all-welded construction. Wheel and blades are riveted and welded for maximum strength, the basic design having been thoroughly tested in the Vacuum Pit, a "Buffalo" exclusive.

AVAILABLE in wheel diameters from 18¼" to 80¾", the new "Buffalo" "BLH" merits your consideration. Write for details on your company letterhead — today.

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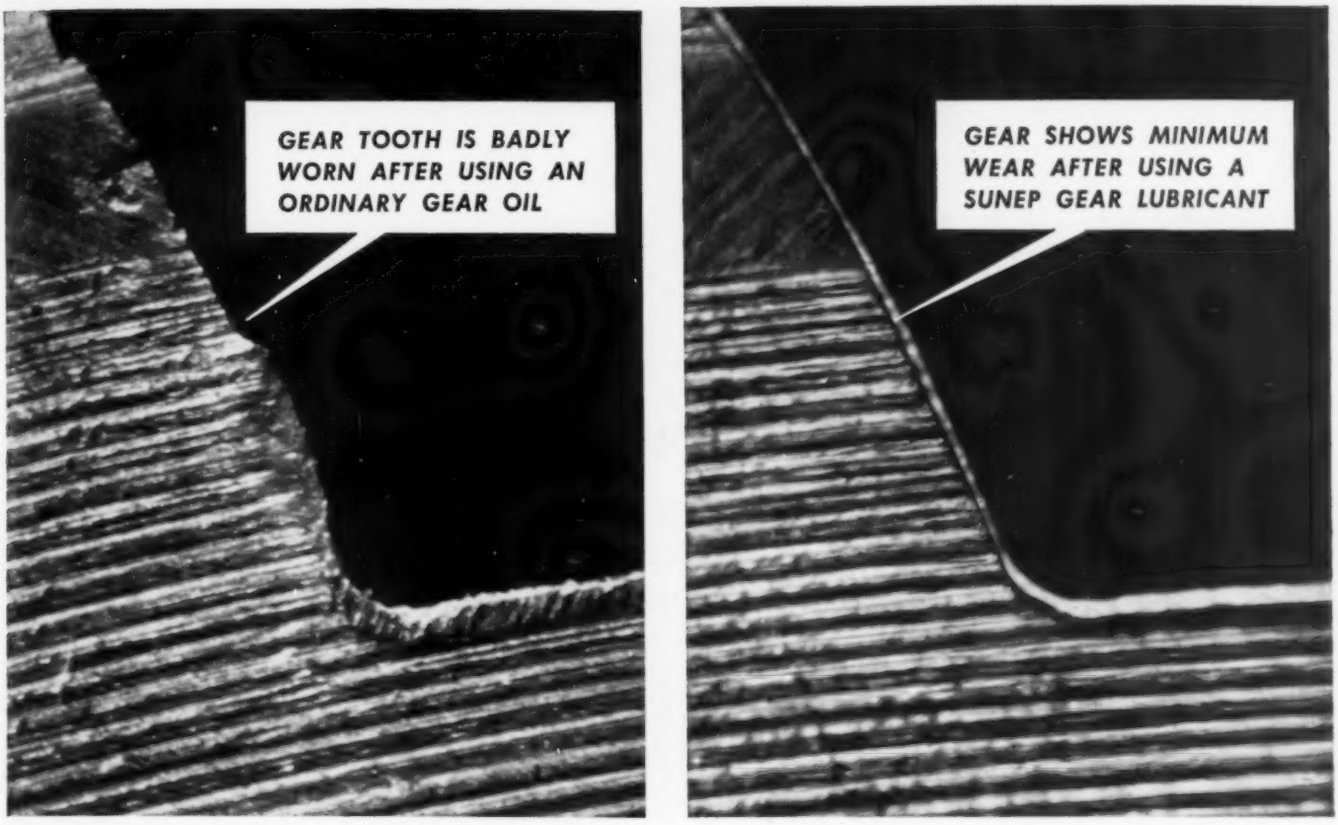

COMPARATIVE TESTS on identical new worm gears demonstrate superiority of Sunep Gear Lubricant. Gear on left, using a compounded cylinder oil, shows excessive wear at 70 hours. Gear on right, protected by Sunep, shows minimum wear after running over 200 hours!

HERE'S PROOF SUNEP GEAR LUBRICANTS MINIMIZE WEAR

Sunep Gear Lubricants cut power losses...protect against overloads ...lengthen gear life...reduce maintenance costs and replacements.

During recent tests gear units protected by Sunep Gear Lubricant showed an absolute minimum of wear when run at normal rated capacity. There was no indication of scoring or wear even when run at overloads up to 118%! Power consumption was reduced up to 25%. Damage from shock loads was nil.

In addition to outstanding load-carrying ability, Sunep Gear Lubricants are extremely stable, non-corrosive, prevent rusting, keep gears and bearings clean.

For complete information about how Sunep Gear Lubricants can help give longer life to your worm gear units, see your Sun representative...or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. IS-2.

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Check first with GASMACO for latest industrial furnace designs.

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GAS PLANT EQUIPMENT
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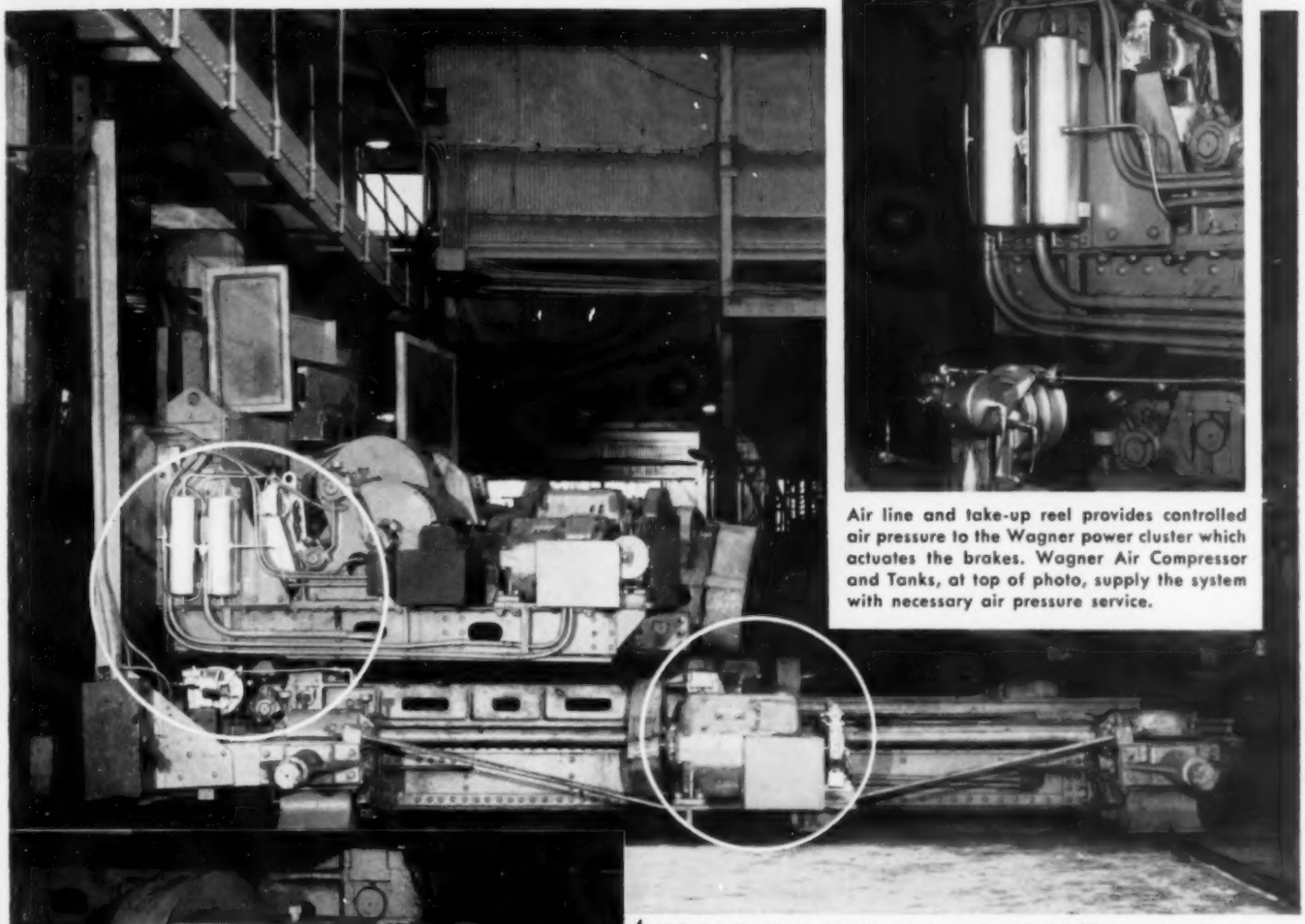
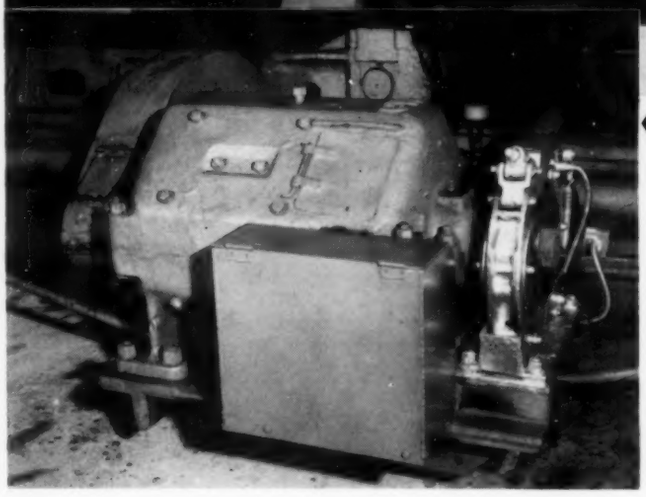


Air line and take-up reel provides controlled air pressure to the Wagner power cluster which actuates the brakes. Wagner Air Compressor and Tanks, at top of photo, supply the system with necessary air pressure service.



U.S. Steel's wheel charging car is equipped with Wagner type H Hydraulic Crane-Bridge Brakes, as shown at left.

Wagner power brake system controls movement of wheel charging machine for U. S. Steel

This 21-ton wheel charging car at U. S. Steel Corporation, Gary, Indiana plant works at high speed to feed an automation line. It takes red hot railroad car wheels from a forging press—carefully places them in a re-heating furnace—moves them to the automated line for shaping, trueing and marking.

A Wagner Air-over-Hydraulic Industrial Power Braking System, especially designed for this application, keeps this machine under complete control. The operators can make safe, sure, precise stops with ease.

Wagner can now offer such Power Brake Systems to meet *your* requirements. Call your nearby Wagner Field Engineer—let him help you make safe, sure stops with your speeded-up charging machines.

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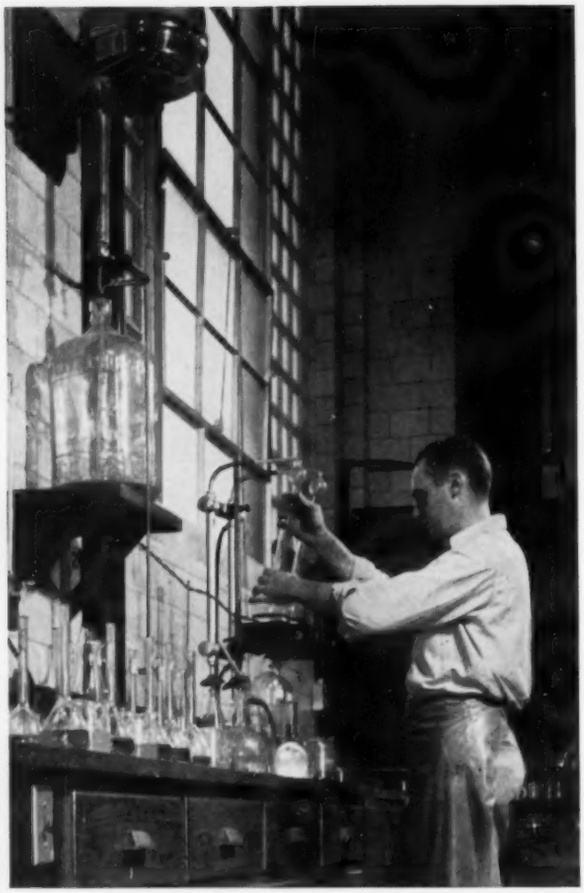
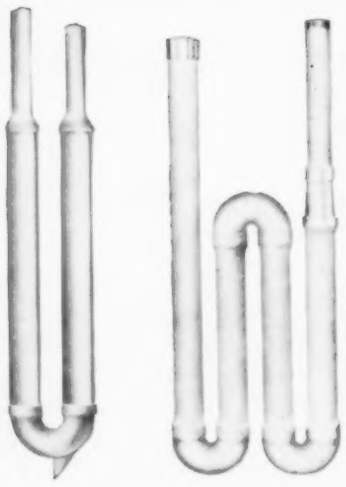


THIS IS A FOUNDRY?

Looks more like a chemical lab, doesn't it? And that's exactly what it is—in the Electro-Alloys plant at Elyria. It's typical of our complete research and metallurgical facilities—which also include X-ray and physical testing laboratories.

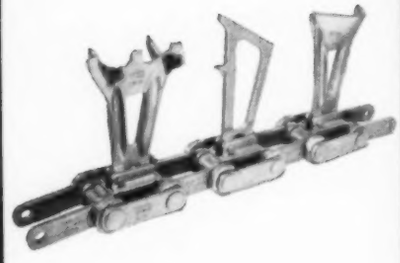
Out of research and metallurgical facilities like this has come the reputation of THERMALLOY* heat-resistant castings—for long-life economy in scores of steel mill applications. Just a few of these are shown below. Your nearby Electro-Alloys representative will be glad to give you full information about them, and many more . . . or assist you with any high-heat-resistant casting problem you may have. Why not call him?

*Reg. U. S. Pat. Off.



Thermalloy Radiant Tubes
Centrifugally cast, X-ray controlled, pressure-tested.

Thermalloy Furnace Rolls
...for roller-bottom furnaces.



Thermalloy Carrier Blades and Chain...Three types of blades, mounted on *Thermalloy* conveyor chain.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION Elyria, Ohio

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Patent Reviews

. . . . Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period September 4, 1956 through September 25, 1956 . . . .

METHOD OF MAKING BARS

▲ U. S. 2,761,204, issued Sept. 4, 1956, to Bryant Bannister, assigned to United States Steel Corp., describes a method for making round bars or billets which are to be further processed into seamless tubes. The bar is made directly from the ingot as cast, without any substantial loss of heat.

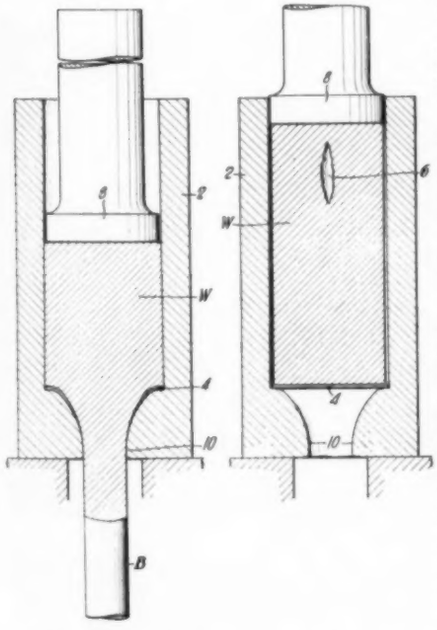
In carrying out the process, a round ingot of steel or other metal is cast in an ingot mold. As soon as it has been cast, the top is sealed by playing a stream of water on it, to form a cap or crust which prevents air from entering as the shrinkage cavity or pipe develops. The ingot is preferably 26 in. in diam by 6 ft in length, and has approximately $\frac{1}{8}$ in. taper per foot of length. After the top of the ingot has been sealed, it is stripped while very hot and placed in the conventional soaking pit to equalize the temperature throughout the ingot. The ingot is then removed and thoroughly descaled, preferably by impinging a jet of high pressure water progressively over the entire ingot surface. The ingot is then immediately charged into the cylindrical container 2 of an extrusion press, as shown in Figure 1.

Before placing the ingot W in the container 2, a plate 4 of glass or glass-like material is placed at the bottom of the container, and the ingot may be coated with a similar material (e.g., it may be wrapped with spun glass cloth). The glass acts as a lubricant, reducing the required extrusion pressure, increasing the life of the die, and minimizing surface defects.

The ingot is placed in the container 2 preferably with the cavity 6 at the top. The ram 8 of the extrusion press is then moved down, compressing the ingot and forcing it out of the forward end of the container through a circular die 10 of the desired diam. Since the ingot is subjected to pure compression during the extruding action and since the shrinkage cavity is sealed against oxidizing gases, the void 6 will be closed during extrusion so that all but a small butt or slug of the metal will be utilized. The reduction ratio is between 4:1 and 60:1. The product diameter is 5 to 13 in.

At no time during the series of operations, does the metal drop below a suitable extrusion temperature. The extruded section B is then sawed or sheared from the butt remaining in the container and is surface conditioned by passing it longitudinally while very hot through a circular oxyacetylene torch which burns off a small amount of the surface. After this operation, the bar is cut into

Figure 1



OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,761,189	9/4/56	Shackle type thimble	United States Steel Corp.
2,761,208	9/4/56	Production of metallic strip	Colin C. Mitchell
2,761,561	9/4/56	Mechanism for handling billets	Morgan Construction Co.
2,761,671	9/4/56	Cupola gas conditioning apparatus	American Radiator & Standard Sanitary Corp.
2,761,826	9/4/56	Coke oven with improved end joint	Koppers Co., Inc.
2,761,827	9/4/56	Bracing means for coke oven batteries	Koppers Co., Inc.
2,761,893	9/4/56	Traveling electric cable	United States Steel Corp.
2,761,986	9/4/56	Impulse-generating device for measuring the length of metal strip	United States Steel Corp.
2,762,217	9/11/56	Furnace wall construction	Laclede-Christy Co.
2,762,245	9/11/56	Rolling mill guide	Louis Swickley
2,762,575-7	9/11/56	Collapsible reel	The Herr Equipment Corp.
2,762,578	9/11/56	Strip coiling apparatus	United States Steel Corp.
2,762,620	9/11/56	Detinning apparatus	Metal & Thermit Corp.
2,762,700	9/11/56	Production of ferrous chloride and metallic iron powder	Richard J. Brooks
2,762,701	9/11/56	Carburizing molten cast iron	Air Reduction Co., Inc.
2,762,703	9/11/56	Process of treating mayari type iron ore containing nickel	Bethlehem Steel Co.
2,762,764	9/11/56	Method of electroplating aluminum on continuous steel strip	United States Steel Corp.
2,762,902	9/11/56	Electrode and roll assembly for tube mills	The Etna Machine Co.
2,763,476	9/18/56	Two stage combustion furnace for heating billets	Metallurgical Processes Co.
2,763,479	9/18/56	Sintering apparatus	Gutehoffnungshutte Sterkrade A.G.
2,763,544	9/18/56	Chromium steel	Nyby Bruks Aktiebolag
2,763,545	9/18/56	Graphitic tool steels	Allegheny Ludlum Steel Corp.
2,763,547	9/18/56	Cast austenitic alloys	Allegheny Ludlum Steel Corp.
2,763,582	9/18/56	Apparatus for producing protective combustion atmospheres	Metallurgical Processes Co.
2,763,583	9/18/56	Production of porous cast iron	Sozo Kawasaki
2,763,784	9/18/56	Continuous measurement of tin thickness of tinned strip	Jones & Laughlin Steel Corp.
2,764,033	9/25/56	Variable-speed drive for rotary shears	United States Steel Corp.
2,764,398	9/25/56	Stub tube refractory tile for recuperators	Amsler Morton Corp.
2,764,435-6	9/25/56	Rail bond	United States Steel Corp.
2,764,473	9/25/56	Apparatus for detinning scrap	National Steel Corp.
2,764,481	9/25/56	Iron base austenitic alloys	Allegheny Ludlum Steel Corp.
2,764,508	9/25/56	Electrostatic strip-oiling apparatus	United States Steel Corp.
2,764,514	9/25/56	Producing steel rods for prestressing concrete	Donovan H. Lee
2,764,515	9/25/56	Spheroidizing steel stock	Surface Combustion Corp.

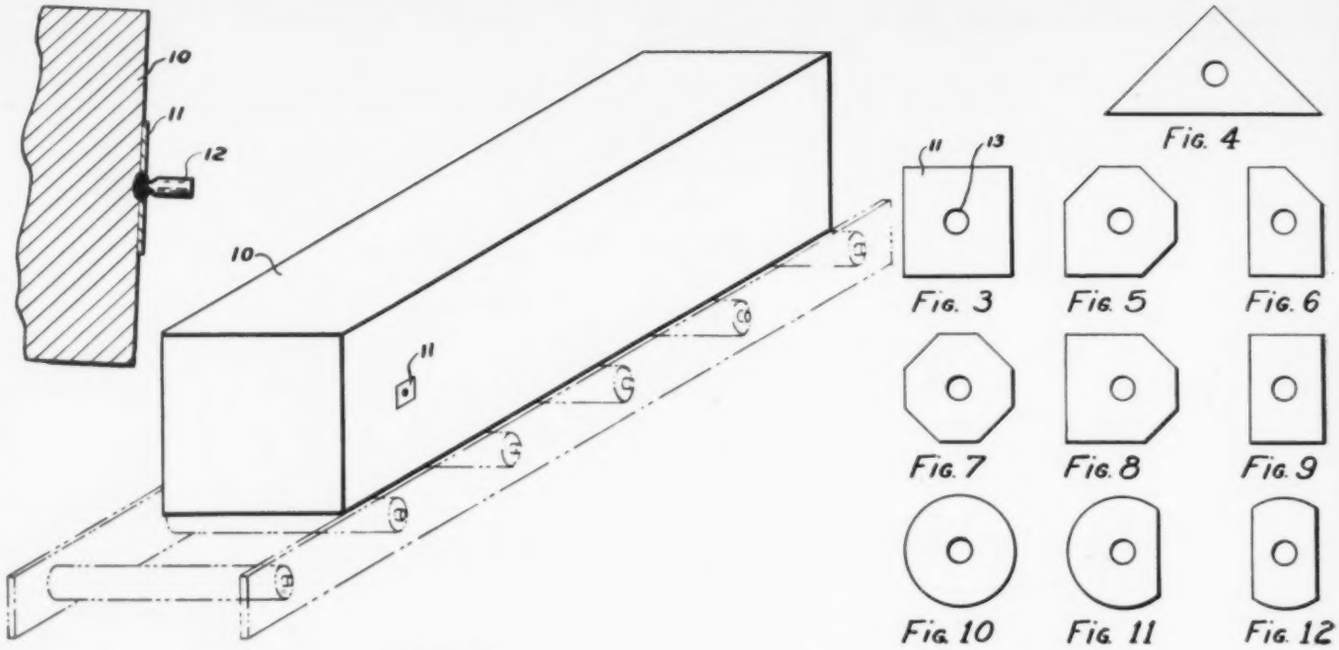


Figure 2

lengths suitable for the seamless mills.

BILLET IDENTIFICATION

U. S. 2,761,229, issued Sept. 4, 1956, to Robert C. Friedly, William G. Tawse, and Robert C. Singleton, assigned to Gregory Industries, Inc., describes a method and apparatus for identifying billets which are being heated close to their melting point, which may be 2000 F or more. Such identification is necessary as the direct result of short run operations in steel mills, when several types of steel are being produced, and when these billets of different kinds of materials are in the furnace at the same time. The identification marker must be easily recognized, since the heat prevents men from working close to the billets for a long period of time.

Figure 2 shows a billet having a marker attached to it. Figures 3 to 12 are plan views of various markers.

The marker 11 in Figure 2 is constructed of metal which will withstand the temperature that the billet will be subjected to during its heating. It is fastened to the billet 10 by end arc spot welding, using a welding stud 12, as shown. The marker is washer- or wafer-shaped, and is provided with the spot weld hole 13. The stud 12 may be grooved and the extension portion broken off to leave nearly a flush weld on the surface of the marker.

BILLET HEATING FURNACE

U. S. 2,762,618, issued Sept. 11, 1956, to John A. Johnson and Robert H. Eustis, assigned to Thermal Research & Engineering Corp., describes a furnace for heating steel billets.

As shown in Figure 13, the furnace 10 consists of an elongated chamber 11 with a cylindrical ceramic wall 12. Two fluid fuel burners 13 provide the source of heat. The products of combustion leave through flue 14, and go through a recuperator 15. Billets 16 pass through the furnace countercurrent to the flow of combustion gases, a pair of injector rolls 17 initiating their entrance into the furnace. The billets move through the furnace on a series of support wheels 19 which project partially into the chamber 11. The means of driving the wheels 19 is shown in Figure 14. The billets pass over a ceramic skid 24 and are pulled out of the furnace by a pair of extractor rolls 25.

The combustion air to the burners 13 is preheated by means of the recuperator 15, and it also receives heat in passing through the conduit 27 which surrounds the chamber 11. As the support wheels 19 rotate, they carry heat from the chamber 11 to the conduit 27.

STAINLESS STEEL PICKLING PROCESS

U. S. 2,762,728, issued Sept. 11, 1956, to Edgar A. Hahn and assigned

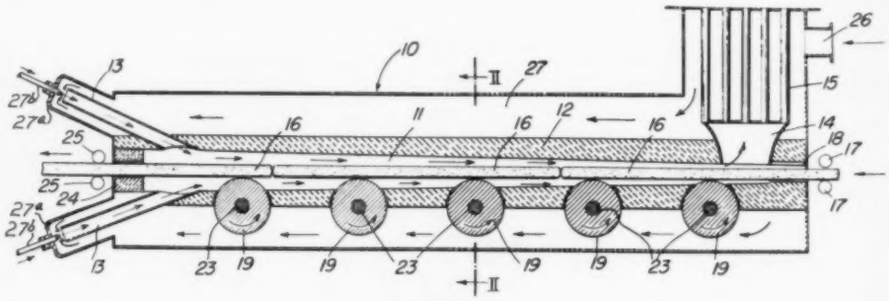
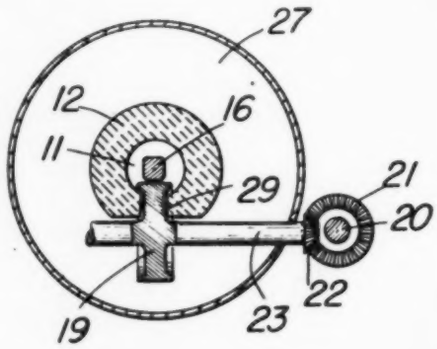


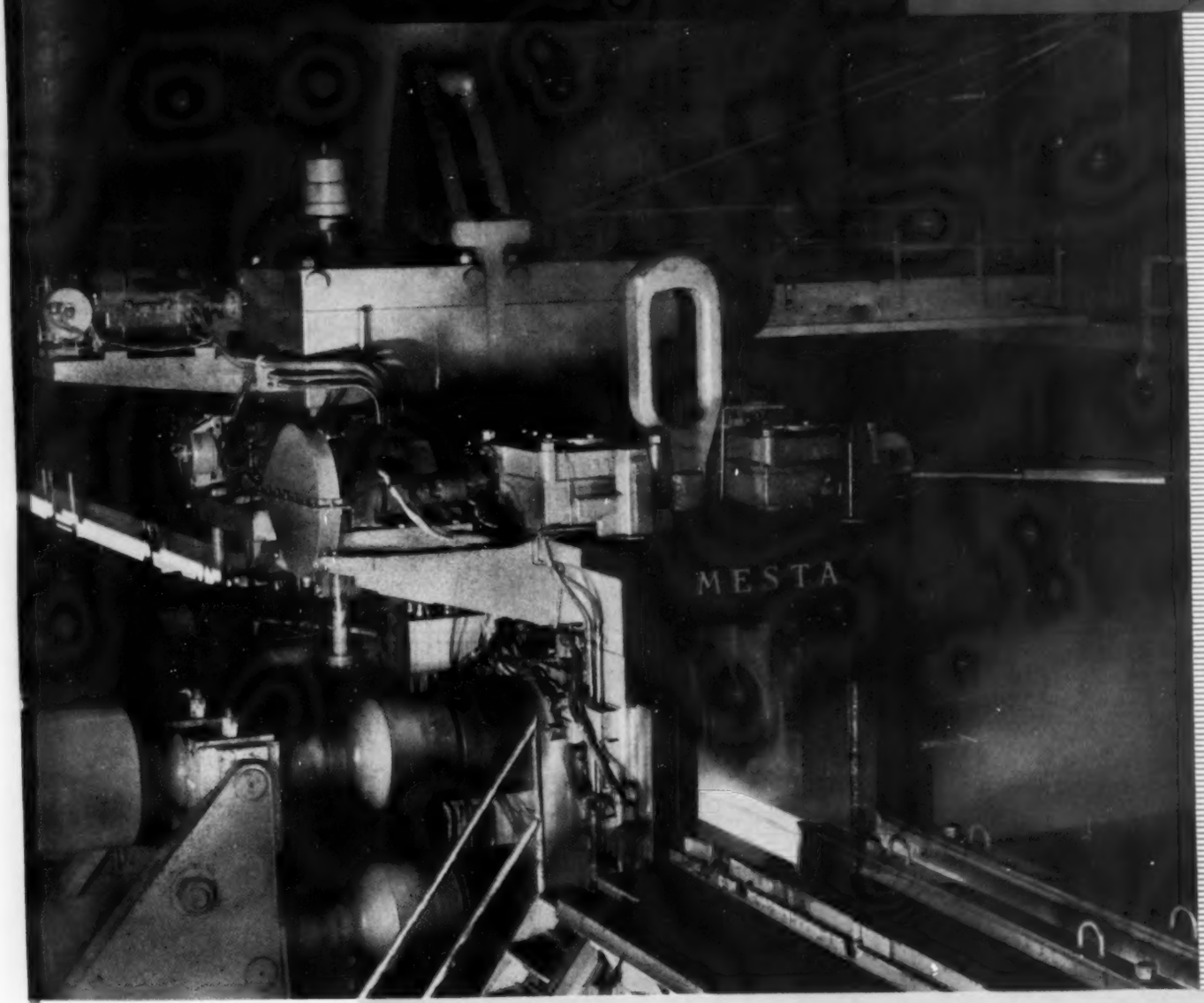
Figure 13

Figure 14



WIDE FLANGE BEAM AND STRUCTURAL MILLS

Designed and Built by MESTA



MESTA Universal Structural Mill rolling wide flange beams on the 44" Universal Stand and the 34" Edging Stand at Inland Steel Company, Indiana Harbor Works

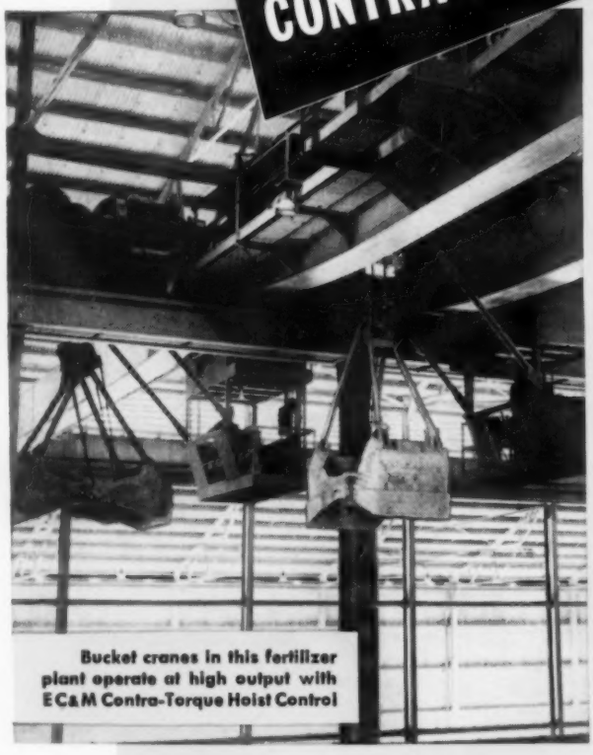
Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

MESTA
THERE IS NONE BETTER

Bucket crane of the Level-Luffing type operates speedily under EC&M Contra-Torque Hoist Control



Bucket cranes in this fertilizer plant operate at high output with EC&M Contra-Torque Hoist Control

HERE'S HOW EC&M FREQUENCY RELAY CONTROL improves A-C Bucket Crane performance

CONTRA-TORQUE®

FAST GETAWAY! Quickly responsive to the frequency of the induced-rotor voltage, **EC&M FREQUENCY RELAYS** match torque requirements to the load. They get the motor up to speed quickly for lowering the bucket and moving the trolley in or out. A lot of time saved between trips!

WIDE SPEED SELECTION! These relays permit pick-up of Contra-Torque lowering connections on any master switch speed point. No waiting until last down point is reached. Wider choice of speed gives greater flexibility in clean-up operations and speeds output!

SMOOTH STOPPING! When checking motor-lowering speed, weak torques are provided for light loads or the empty bucket; stronger torques for heavier loads. Trolley motor is stopped and reversed smoothly under frequency relay automatic operation!

SPEED-LIMITING! Safety on all speeds. These relays (one set for hoisting and lowering) automatically shift motor connections to safeguard lowering operation with far greater skill than human hands.

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

7407

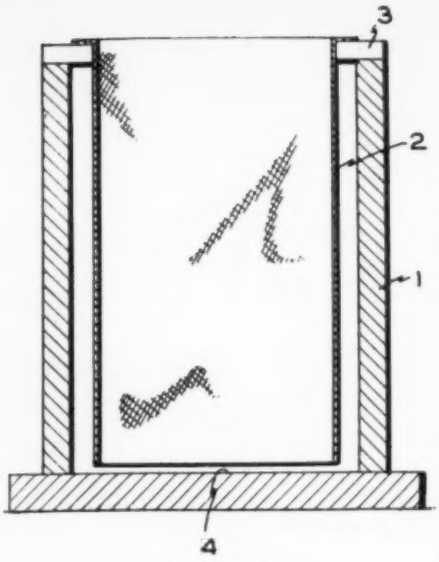


Figure 15

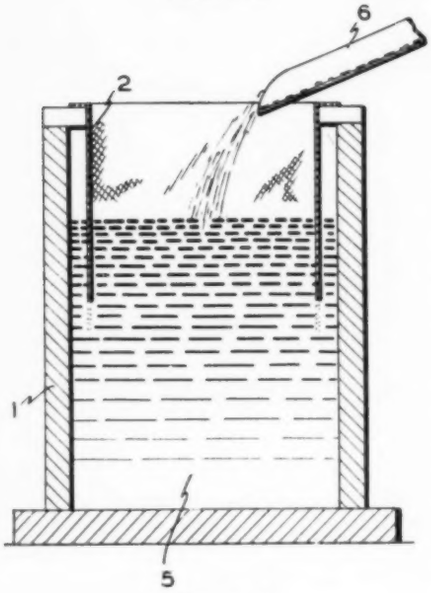


Figure 16

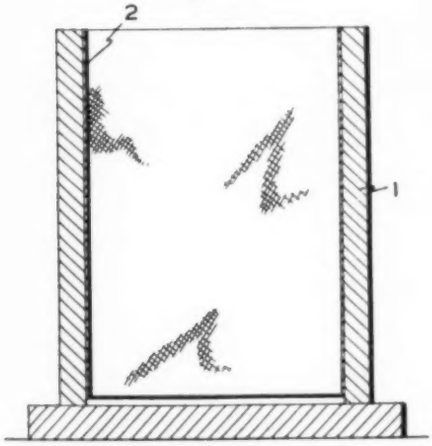
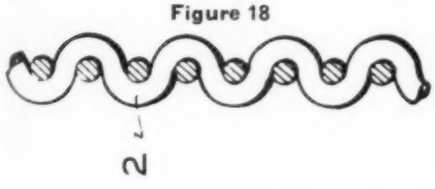


Figure 17

Figure 18



to Lyon Inc., describes a method of pickling wrought stainless steel of the chrome-manganese type with a mixture of sulphuric acid and nitric acid. The concentration of nitric acid in the pickling solution is 8 to 12 per cent and that of sulphuric acid is 10 to 15 per cent, and the pickling temperature is 140 to 160 F.

The extremely active chemical combination of sulphuric acid and nitric acid results in effective removal of even the most chemically inert oxides, and this removal takes place down to the bare metal surface. As soon as the bare metal surface is reached, however, the nitric acid (coupled with the unique inertness of the stainless steel) renders the steel surface passive towards corrosion.

REMOVING SCALE FROM WORKPIECES

U. S. 2,762,729, issued Sept. 11, 1956 to Roland B. Snow and assigned to United States Steel Corp., describes a process for the removal of scale from steel which has been heated to forging temperatures, without a substantial heat loss.

According to the inventor, furnace scale can be liquified and thereby removed from steel at a considerably lower temperature than the fusing temperature of scale, which is ordinarily above 1400 C. This is accomplished by contacting the furnace scale with lime at a temperature between 1080 and 1400 C. The scale becomes a very fluid liquid which will either flow off or can easily be blown off the heated metal.

The process is equally applicable to all carbon and low alloy steels, though it is not particularly effective for removing scale from steels containing large amounts of chromium or nickel or both.

The slag resulting from liquifying scale with lime can be used in charging open hearths, thus recovering the iron.

CONSUMABLE GLASS FIBER INGOT MOLD LINER

U. S. 2,763,043, issued Sept. 18, 1956, to Nicholas J. Grant and assigned to Lukens Steel Co., describes a method of casting steel ingots free of surface imperfections and defects, making use of a liner of glass fibers.

In Figures 15, 16, 17, 18 the numeral 1 represents an ingot mold. Supported by means of suspension elements 3 within the mold is a fiber glass liner 2. Molten metal 5 enters the mold from a pouring spout 6. The liner 2 prevents the splashing from striking the mold wall and forming surface imperfections on the ingot. The fiberglas melts away at the contact surface, as shown in Figure 16.

A single thickness of woven fiberglas cloth which is 0.040-in. thick works best.

INTRODUCTION OF BORON INTO STEEL

U. S. 2,755,181, issued July 17, 1956, to Etienne Spire and assigned to L'Air Liquide, Societe Anonyme pour l'Etude et l'Exploitation des Procedes George Claude, describes a process for introducing boron into steel in order to increase its hardenability, thereby replacing manganese, nickel, chromium, or molybdenum.

The normal procedure to add boron to steel is to use ferro-boron, borax, or complex ferro-alloys. However, the results have not been satisfactory, because there is much variation in the recovery and a danger of hot-shortness and brittleness resulting from overdosing the steel with boron, i.e., adding more than 0.006 per cent boron. Another difficult problem is the control of nitrogen in the steel and the proper proportioning of boron to nitrogen.

The invention disclosed in this patent avoids these difficulties by simultaneously reducing the acid soluble nitrogen content in steel, while introducing boron from a reducible borating agent such as alkali metal borate or an alkaline earth metal borate or boron oxide, reduced with a reducing agent such as aluminum or carbon. The operation is performed in a ladle. The nitrogen is continuously eliminated by flushing the metal with a non-oxidizing nitrogen-free gas such as argon or helium. This flushing or bubbling action also strongly agitates the free surface of the metal, thus stirring the highly basic slag to which the borating agent and reducing agent have been added.

Would pitch-impregnated nipples save us money?

Let's call Great Lakes Carbon — they've always been helpful, and they're good people to work with!

ELECTRODE GLC DIVISION

GREAT LAKES CARBON CORPORATION

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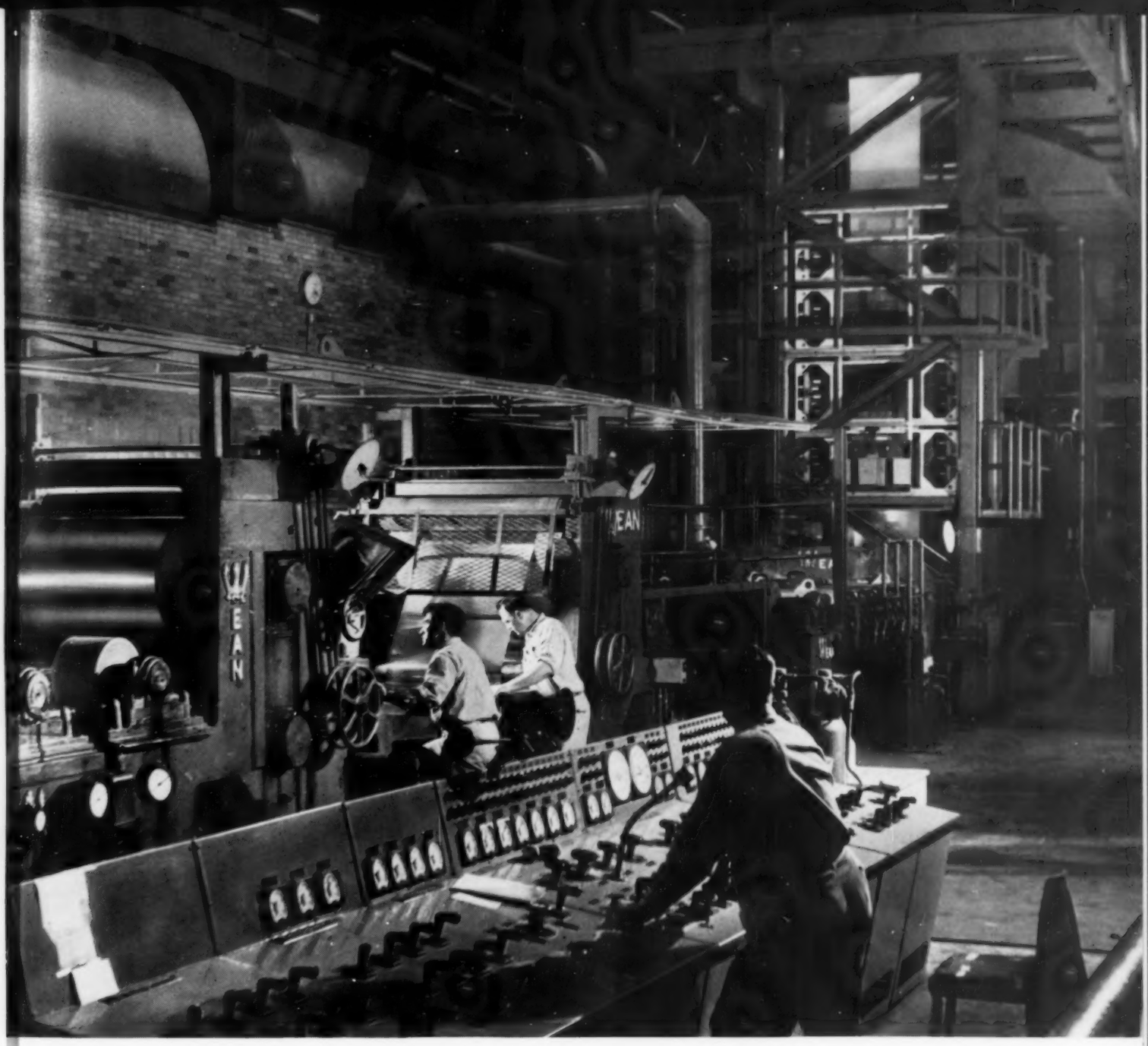

More tin plate . . . mirror finish, precise alloy

Westinghouse line drive and control equipment for exacting, high-speed reflow methods helps your electrolytic tinning lines produce more salable tin plate . . . faster.

Here's how you can give your tin plate a competitive edge ⟶

YOU CAN BE SURE...IF IT'S Westinghouse

With Westinghouse radio-frequency equipment . . .

Smooth, lustrous tin plate at speeds of 2100 fpm, and beyond

Westinghouse equipment for tin-plate reflow operations helps you produce the delicate alloy balance necessary to form tin cans easier, maintain high production rates.

Westinghouse radio-frequency induction heating equipment for high-speed lines . . . both horizontal and vertical acid type . . . keeps coating thickness precise and constant by automatically adjusting plating current in proportion to line speed. Electromagnetic induction, transferring power to the strip without physical contact, melts the tin and creates a bright, nonporous surface.

This process works so fast that it produces an actual flow line on the moving strip. A photoelectric scanner continuously scans the flow line and uses it to maintain heating at the precise, desired level. There's no overheating or underheating . . . the electric equipment is capable of maintaining speeds of 2100 fpm and beyond. You save valuable tin, reduce menders and boost output of prime tin plate. Production scheduling is simplified because photoelectric scanner handles most changes in gauge and speed without adjustment.

How Line Control Operates

Magamp* magnetic amplifier regulators (VR) control voltage of the entry, main and delivery generators assuring fast, even acceleration and deceleration and minimum loop variation during steady operation. Loop regulators act as verniers in controlling generator voltages.

Magamp current regulator (CR) for booster and Magamp counter emf regulator (CEMFR) for motor work together to maintain regulated tension by the pay-off reels (POR) and winding reels (WR). Inertia compensation (IC), proportional to accelerating loads and stall tension signals, is introduced through the (CR) circuits.

Photo-thyratron loop regulators (LR) provide modulated control of storage loops for smooth operation.

Electronic regulators control top and bottom plating current to deposit proper tin coating on each side at all line speeds.

Machine characteristics are selected for optimum drive performance. Entry section pinch roll (PR), master bridle roll (MBR), and drag bridle No. 2 (DB-2), the pace setters of their respective line sections, are shunt-wound for flat speed-load characteristics. Tank drives (T) have high drooping characteristics which result in their developing only the power required to overcome their friction losses and inertia loads. Reel motors have overload capacities suitable for accelerating the large coils now used in most mills.

*Trade-Mark.

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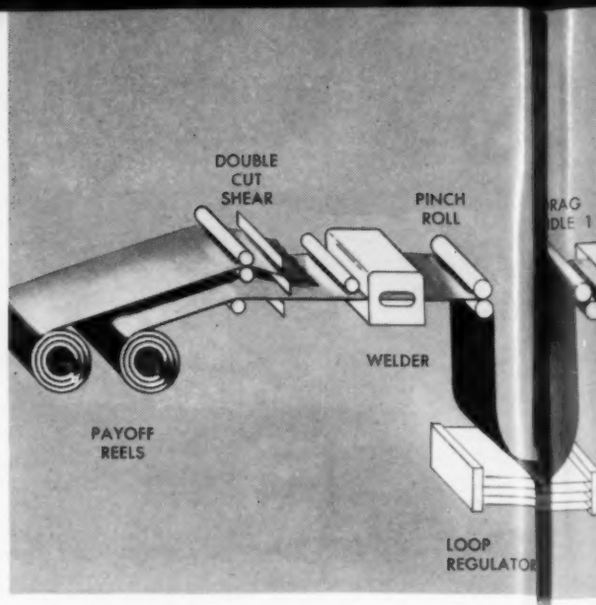
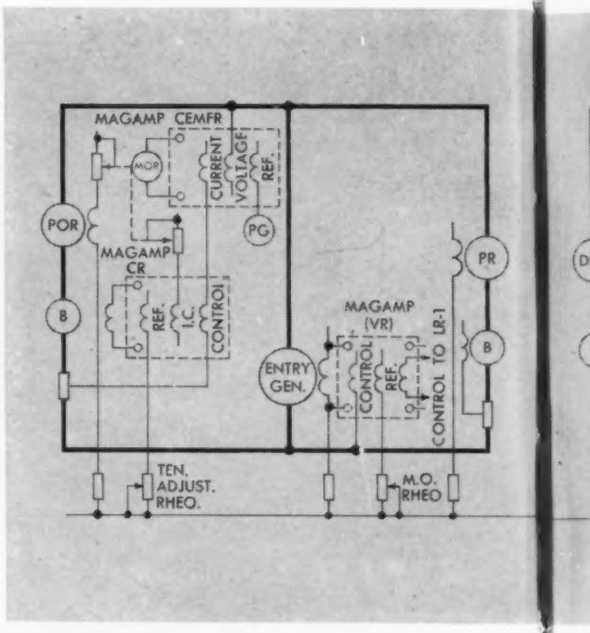
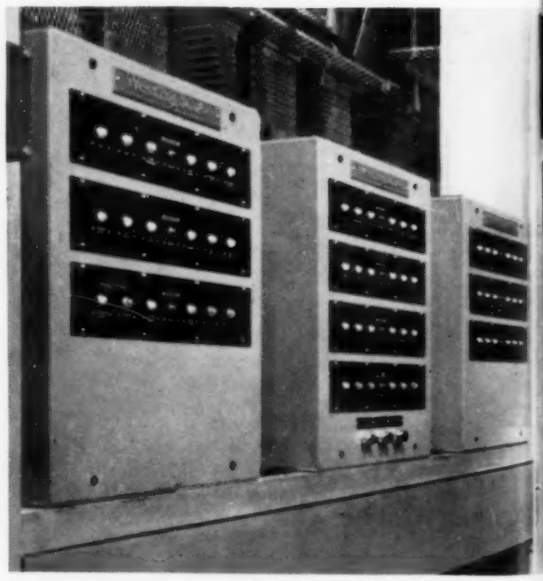
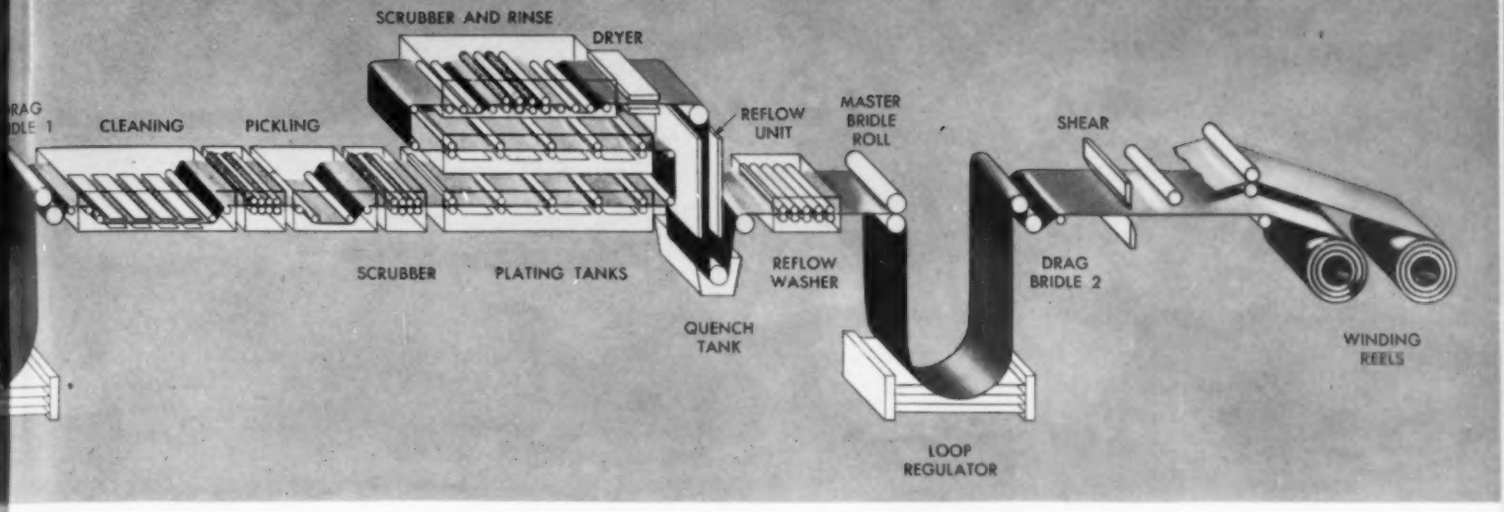


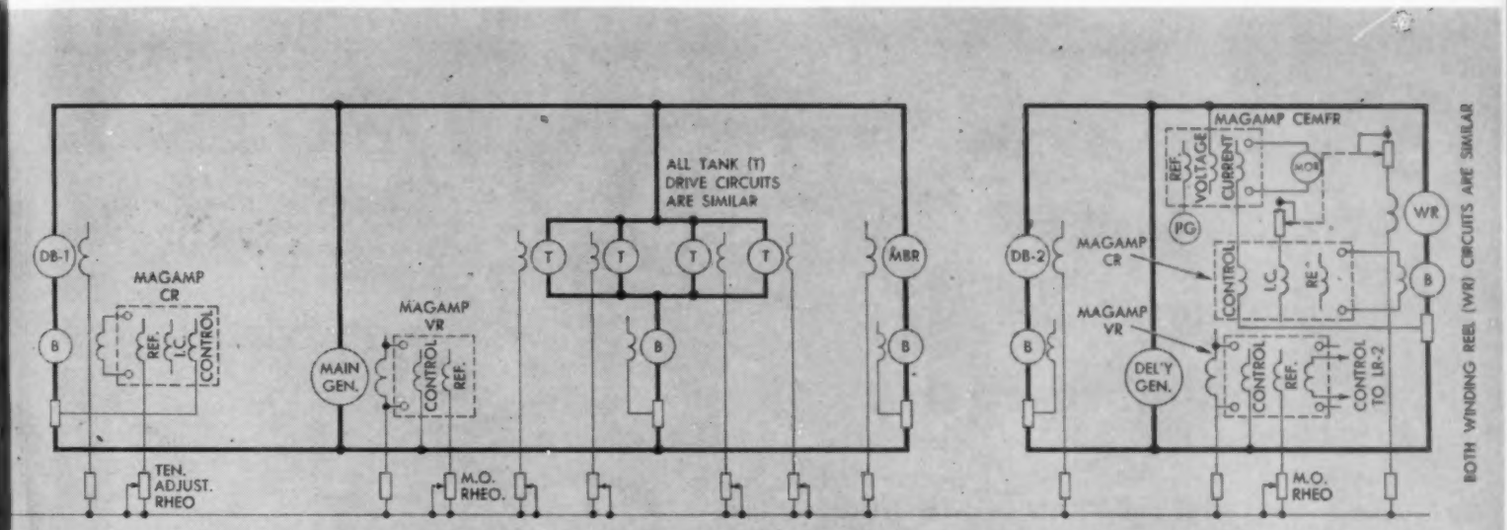




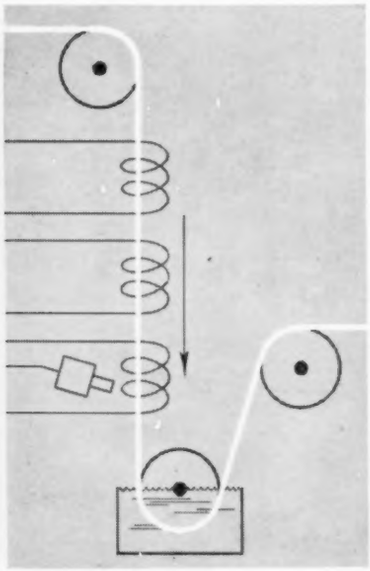
New Westinghouse fault finder monitors control circuits simultaneously, indicates system faults instantly . . . remembers them . . . makes trouble shooting easy.

ELECTROLYTIC TINNING LINE





Westinghouse 2400-kw oscillator equipment supplies high-frequency power to inductor coils. Generator output can be raised or reduced 90% in a couple of seconds.



Photoelectric scanner measures light reflection of passing strip, regulates radio-frequency power application in fraction of a second through saturable reactor.

WESTINGHOUSE EQUIPMENT SERVES THESE USERS

COMPANY	LOCATION	RATED LINE SPEED FPM	TIN FLOW EQUIPMENT
Jones & Laughlin Steel Corporation	Aliquippa, Pa.	600	600 kw, RF
Jones & Laughlin Steel Corporation	Aliquippa, Pa.	2100	1800 kw, RF
Republic Steel Corporation	Niles, Ohio	1000	1000 kw, RF
Republic Steel Corporation	Niles, Ohio	1400	1400 kw, RF
Steel Mill	California	1500	3000 kva, conduction†
Weirton Steel Company‡	Weirton, W. Va.	1300	1200 kw, RF
Weirton Steel Company	Weirton, W. Va.	1300	1200 kw, RF
Weirton Steel Company	Weirton, W. Va.	2100	2400 kw, RF
Weirton Steel Company	Weirton, W. Va.	2100	2400 kw, RF
Youngstown Sheet & Tube Company	Indiana Harbor, Ind.	600	600 kw, RF
Youngstown Sheet & Tube Company	Indiana Harbor, Ind.	2100	2400 kw, RF†

†Not yet in operation. ‡Division of National Steel Corporation.

Several other electrolytic tinning lines have Westinghouse conduction or radio-frequency reflow heating equipment, but line drives of another manufacture.

Westinghouse d-c motors withstand tough treatment because Bondite* and Bondar* insulations have twice the life expectancy of ordinary insulation. This means longer service from drive system, as well as the motors. *Trade-Mark

World's fastest tinning lines are Westinghouse-equipped

Engineering for electrolytic tinning lines is the most demanding in a steel plant, and Westinghouse pioneering in this field dates back to early attempts to deposit tin electrolytically on steel strip. Westinghouse has supplied all the electric line drive and tin reflow equipment for the higher speed horizontal acid type lines, and is now building equipment for the highest speed, vertical acid type.

The fastest tinning lines have as many as 150 individual d-c motor drives. Combining these drives, the generators that supply power to them, the 12 to 15 operators' stations, and the 100-foot-long controller into a coordinated drive system requires the kind of engineering and manufacturing talent Westinghouse can give you.

Reflow equipment, electro-cleaning and chemical treatment generators, switchgear, and numerous individual a-c motor drives and controls for pumps, scrubbers, welders and machinery adjustments must also be integrated into the system.

From planning to design, installation and start-up . . . Westinghouse brings decades of experience to you. A Westinghouse team will accept unit responsibility, and work with your engineering staff and consulting engineers in setting up your tinning line.

Contact your Westinghouse sales office for further details. Ask for a copy of B-6072, *Westinghouse Drives for Processing Lines.* Or write, Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pennsylvania.

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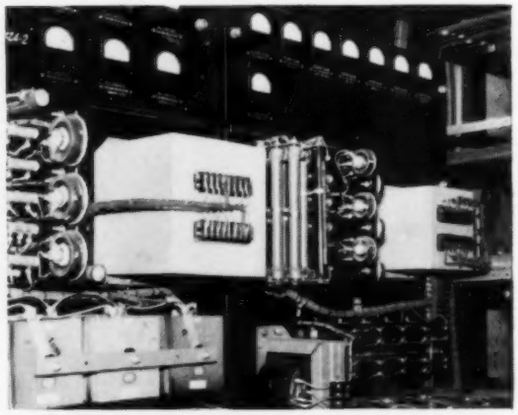
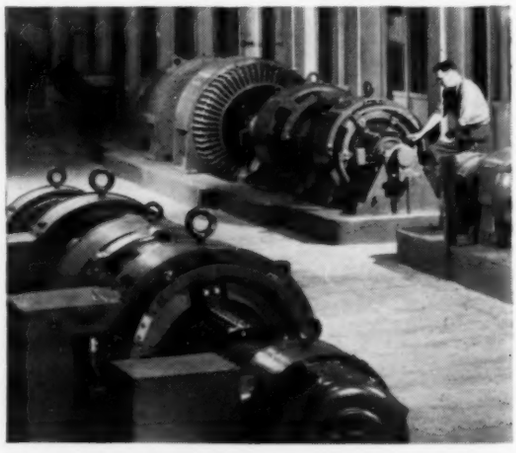
Westinghouse



Magamp regulators have no moving parts, brushes, commutators, bearings . . . bring outstanding precision, dependability to line drive control.



Westinghouse large motor-generator sets are built with Thermalastic® insulation which provides 20% greater dielectric strength, 10 times greater voltage endurance, 30 times greater tensile strength than ordinary insulation.

MP-3047

As time goes by, Rust-Oleum long wear assures lower cost over-the-years protection!

Rust-Oleum is distinctive as your own fingerprint. Accept no substitute.

Rust-Oleum's *unusual* resistance to extremes in rust-producing conditions—from sun and salt water to humidity, moisture, fumes, and weathering—assures you of lasting beauty. Long wear made possible, because Rust-Oleum's *specially-processed fish oil vehicle* works down through the rust into the tiny, microscopic pores in bare metal to STOP RUST. Important savings are realized by applying Rust-Oleum 769 Damp-Proof Red Primer *over rusted metal* after scraping and wire-brushing to remove rust scale and loose rust—as costly surface preparations are usually eliminated. See how Rust-Oleum can save you money... in your plant, or your home. Prompt delivery from Industrial Distributor stocks. Write for illustrated literature with color charts.

RUST-OLEUM CORPORATION • 2443 Oakton Street • Evanston, Illinois

RUST-OLEUM®

MANY ATTRACTIVE COLORS

Rust-Oleum finish coatings in Aluminum, White, Red, Gray, Green, Blue, Black, and Yellow provide double protection for tanks, machinery, girders, equipment, metal sash, wire fences, etc. Write for illustrated literature with color charts.

STOPS RUST!®

Rust-Oleum and Stops Rust are brand names and registered trademarks of the Rust-Oleum Corporation.

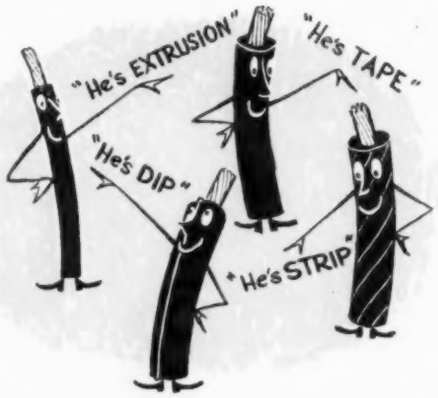
Radioactive tracing studies prove Rust-Oleum penetration through rust to bare metal.

Listen, friends, to the hideous fate of the man who learned about cables too late

Lucius K. Watt was an engineer
He was eager and honest and able,
And one of the things he did for his firm
Was to buy electrical cable.

Now he knew all the people at Okonite
But with orders he'd seldom reward 'em,
"Because," he would state, "the cables are great
But who in the world can afford 'em?"

(Now that was a fault of the late Lucius K's—
That he had such a silly illusion;
For Okonite insulates cables *all* ways:
Strip, taping, dip and extrusion.



Only Okonite uses all methods, you see—
Our prices are *not* always highest;
And thus when you ask us what cable to use
Our recommendation's unbiased.)

So Lucius K. Watt went out and he bought
A cable he heard was a bargain
And this was too bad, for Lucius was had . . .
By some Madison Avenue jargon.

The thing was installed (with a minor defect)
In a most inaccessible place;
When Lucius K. Watt went out to inspect . . .
The cable blew up in his face!

We hate to relate this horrible fable
But here is the moral for all:
If you should desire a superior cable—
By extrusion or strip . . . by taping or dip
Just write us a letter, or call.

No matter *what* insulation or method of application you want (and we use them all) you'll get the best of its kind from Okonite. For a frank, down-to-earth discussion on cable insulating methods, write for Bulletin IS-1106, The Okonite Company, Passaic, N. J.

where there's electrical power . . . there's **OKONITE CABLE**

4754

VICTOR R. BROWNING MILL TYPE CRANES TO SPECIFICATION...

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.
WILLOUGHBY (CLEVELAND), OHIO
DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

"We forged 10-foot rings from a 5-foot ingot... in stainless steel"

says **John Matthews,**

U. S. Steel General Foreman—Forging

It required many days to take the photographs on this page, days of forging and re-heating. The forgings are made from type 304 stainless steel, and they're destined for a nuclear power plant. Now read why it took so long to make them.

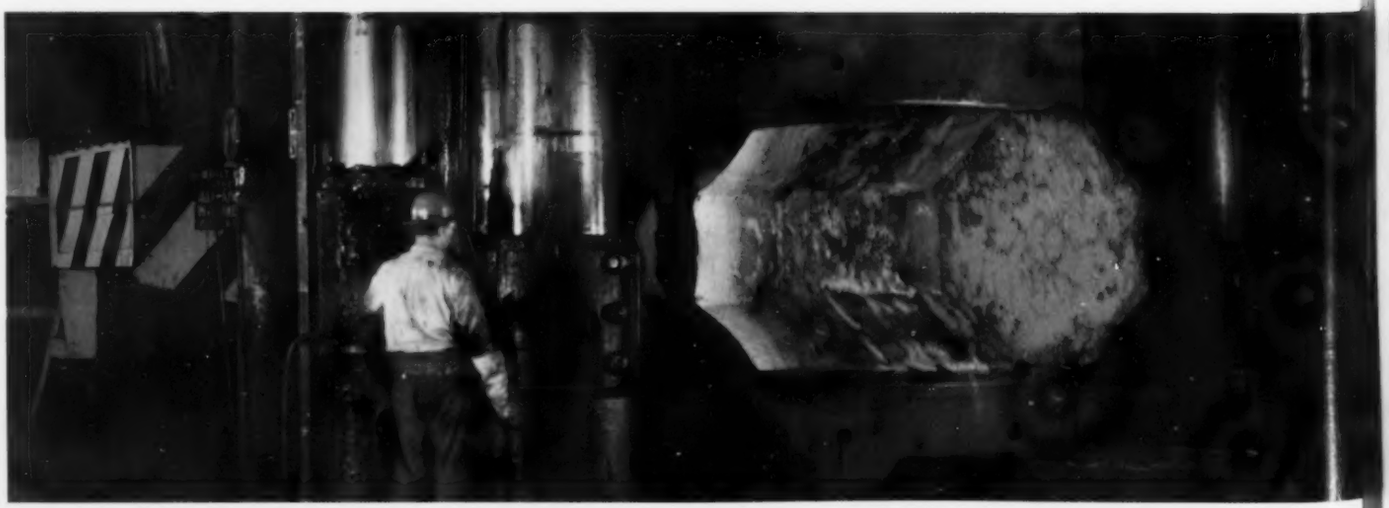
Stainless is strong and stiff, even at forging temperatures. It requires more passes through the press, more die pressure, and the dies wear out faster. If you forge it too long, so that it gets "cold," it will develop small surface cracks beneath the great jaws of the press.

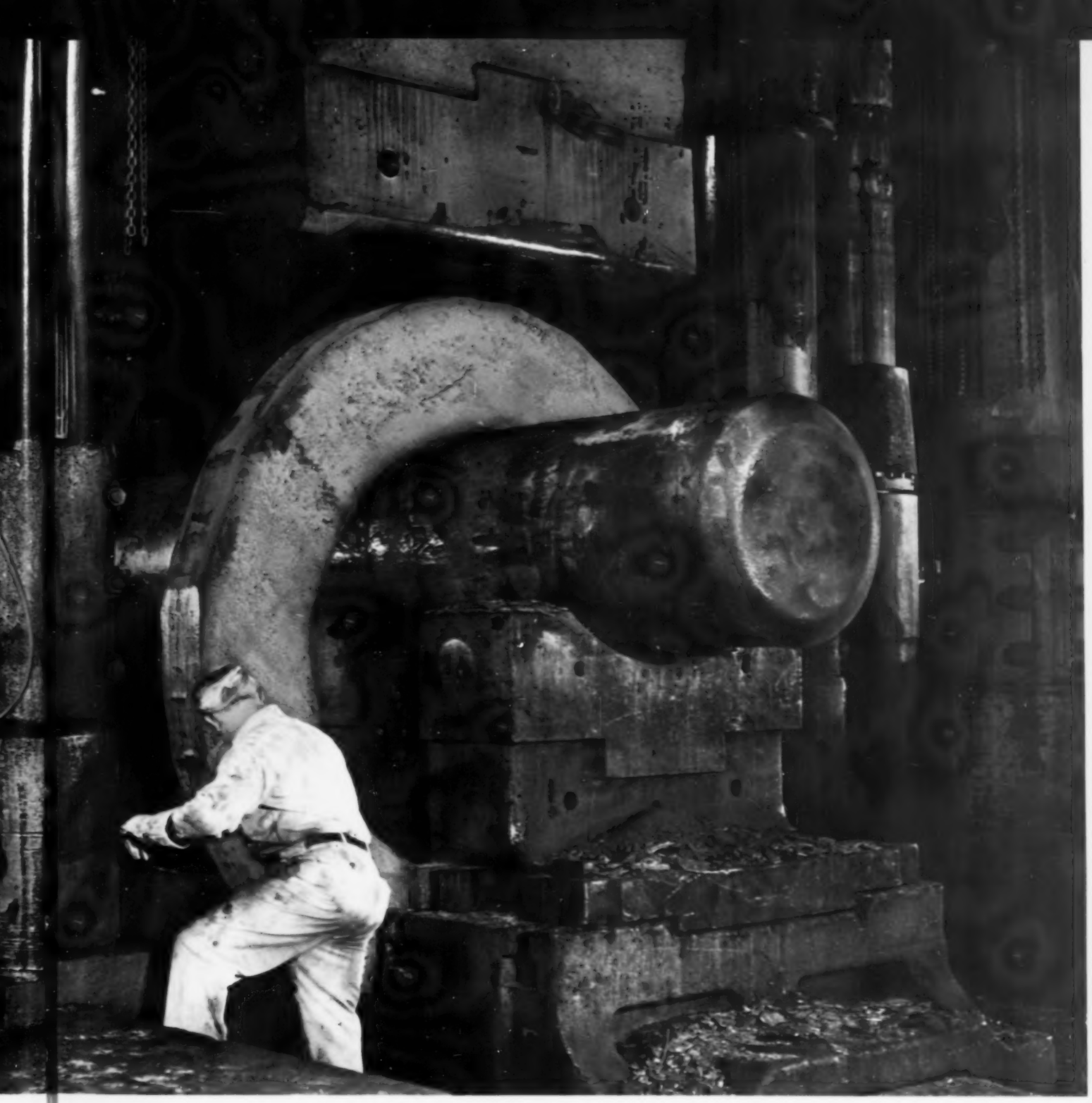
In John Matthews' words:

"We started with a 59″ fluted ingot and forged it down to a 40″ octagon, then sliced it into three flat discs. The thickest disc was forged down to 18″, and we put a 23″ hole through it with steel punches. Then it was worked over the big steel mandrel to finished size: 119″ outside diameter, 80″ inside diameter, 10½″ thick. The other two rings were somewhat thinner."

It was a tricky job, but USS Quality Forgings like this are being turned out every day because we've got the men with the skill to do the job right.

We'll certainly appreciate your inquiries. Send them, or requests for our free 32-page booklet on USS Quality Forgings to: United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.





USS QUALITY FORGINGS

heavy machinery parts . . . carbon, alloy, stainless
forged steel rolls and back-up roll sleeves
electrical and water wheel shafts
specialty forgings of all types

UNITED STATES STEEL

On this punishing assignment...

Louis Allis motors sturdily absorb severe physical abuse

Providing the power for a car-shaker is a punishing assignment for an electric motor. It's a tough test, calling for physical characteristics not usually demanded of electrical rotating equipment. The slightest flaw in mechanical design or construction may result in destruction of the motor.

Here's where Louis Allis special-motor engineering talent met and solved a tough materials-handling problem. Here's where really *solid* industrial construction and quality features pay off in dollar-saving uninterrupted material movement. Features like special bearing construction eliminate end play . . . take heavy loads . . . lengthen bearing life. They'll pay off in your plant, too.

Ask a Louis Allis sales engineer to survey your materials-handling motor and drive needs. He's a motor expert and will make sound recommendations, without obligation, of course.

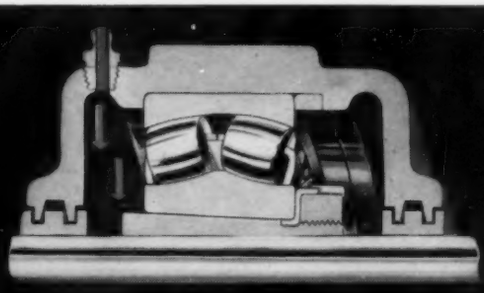
Get the Louis Allis "Consolidated Catalog," Bulletin 105. Contact your nearby Louis Allis District Office, or write The Louis Allis Company, 450 East Stewart Street, Milwaukee 1, Wisconsin.

LOUIS ALLIS

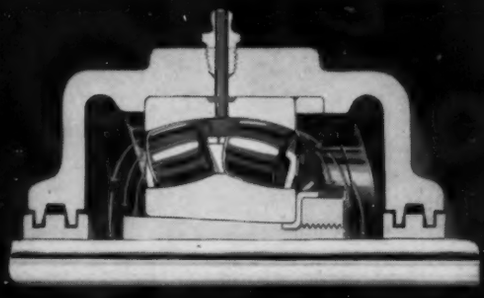
LA-114

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE-SPEED DRIVES

At No Extra Charge ... A MAJOR IMPROVEMENT IN LUBRICATING SPHERICAL ROLLER BEARINGS



Originally, lubricant entered the bearing housing via a fitting in the side of the housing cap. Flow path was through the bearing.



NOW, the lubricant is introduced through a fitting in the center of the housing cap and moves along a groove that is machined around the circumference of the outer ring. Equally spaced holes drilled in the ring permit the lubricant to enter the center of the bearing.

Nobody but SKF Offers This to You on Spherical Roller Bearings

Once again **SKF** offers another important innovation in spherical roller bearing design. Available in spherical roller bearings 140 mm (5.5118") O.D. and larger, this feature represents a still further improvement to the proven **SKF** Type "C" Spherical Roller Bearing.

The new design allows the lubricant to enter at the *center* of the bearing and move outwardly – completely covering all working surfaces. Old lubricant is flushed away from the bearing and, with it, any abrasive dust, dirt, moisture, or other impurities.

You can use this improved bearing in your existing housings simply by moving the lubrication fitting to the center.

Here again is an example of how **SKF** helps you to obtain longer bearing life, at no added cost. Send for Bulletin No. 443 for complete details. 7751

EVERY TYPE—EVERY USE

SKF®

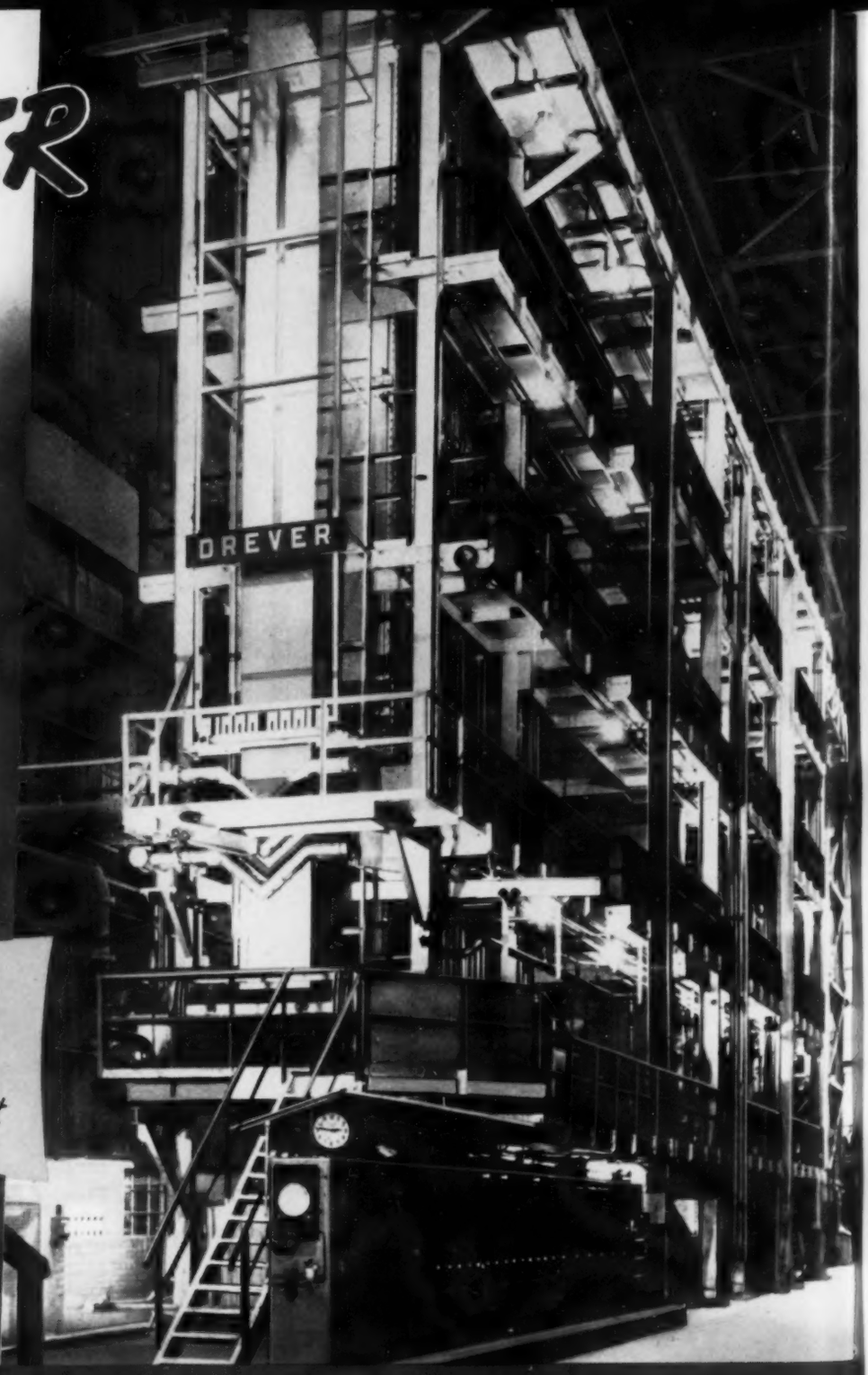
- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings* ("Tyson")

*Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

DREVER

Continuous STRIP ANNEALING FURNACE LINE



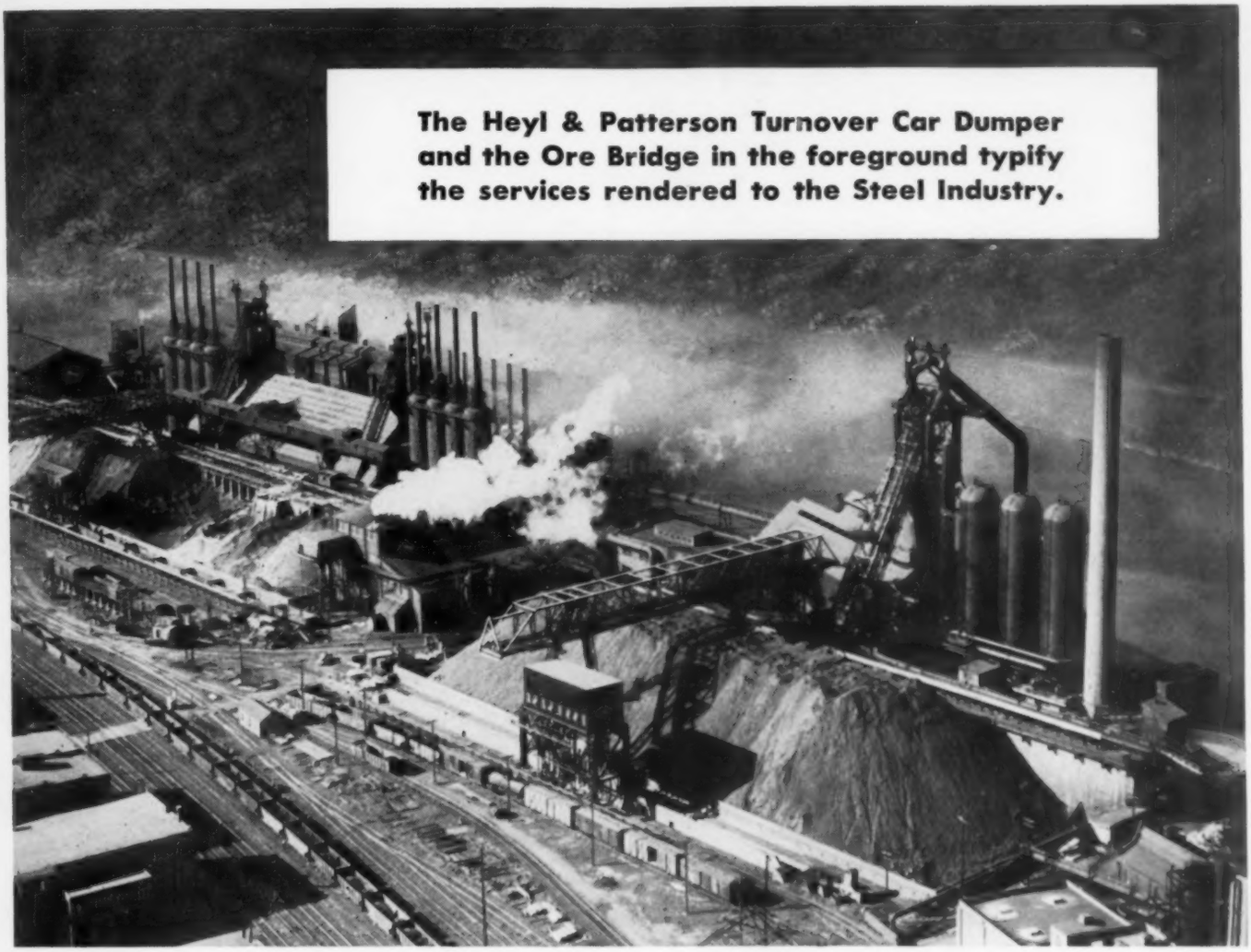
Delivery end of furnace for low carbon tin plate strip installed in a large Canadian steel plant.

This furnace has an installed electrical input in heating and soaking zones of 3000 KW for a rated production of 37,000 lbs/hour on .0099″ x 33″ wide strip running at 550 FPM.

Furnace equipment is designed to handle strip in thicknesses from .0075″ to .020″ in widths varying from 19″ to 38″.

HNX atmosphere gas is used to purge the furnace.

DREVER COMPANY ..... RED LION ROAD and PHILMONT AVE., BETHAYRES, PA.



The Heyl & Patterson Turnover Car Dumper and the Ore Bridge in the foreground typify the services rendered to the Steel Industry.

From railroad car to blast furnace high-line

the handling of ore is entrusted to Heyl & Patterson equipment. The stock pile is wider and higher, the operation more economical, and storing and recovering of ore is accomplished at higher rates of speed.

Every time you install an H&P Traveling Turnover Car Dumper or an H&P Ore Bridge, or both as in this plant of The Pittsburgh Steel Company at Monessen, Pa., you are employing the best tools for bulk material handling.

Over 70 years, H&P engineers have established a reputation for our products. We strive to continue in the forefront of progress.

Barge and Boat Unloaders

Barge and Car Haul Systems

Car Dumpers: Rotary, Turnover

Coal Bridges

Hydraulic Buffers and Rail Clamps for existing Bridges, Gantry Cranes and Unloaders

Ore Bridges

Pig Casting Machines

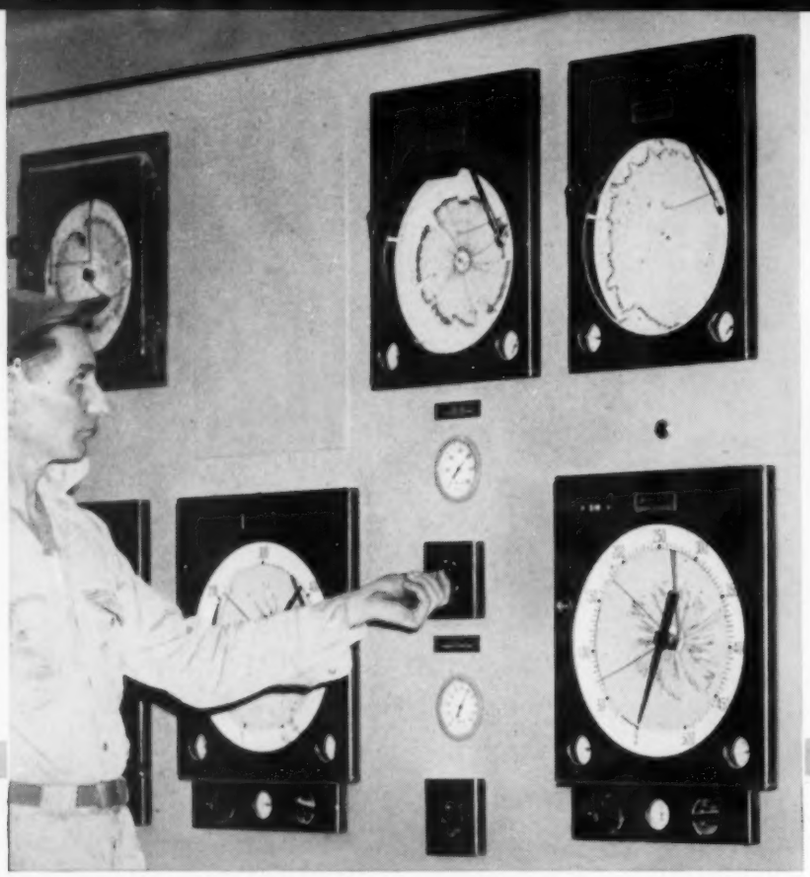
Specialized Conveying Systems

When Experience Counts...

Count On Heyl & Patterson

Heyl & Patterson
INC.

55 FORT PITT BLVD., PITTSBURGH 22, PA. • COurt 1-0750



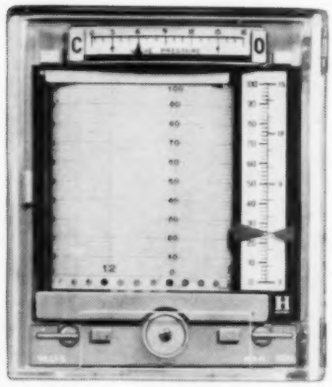
Honeywell

At the turn of a dial, the furnace operator can set the required total Btu input for a multiple-fuel open hearth furnace. The Honeywell Fuel-Air Ratio control system automatically uses as much byproduct coke oven gas as is available, adds oil as needed for the total Btu input, and adjusts both fuel and air in correct proportion.

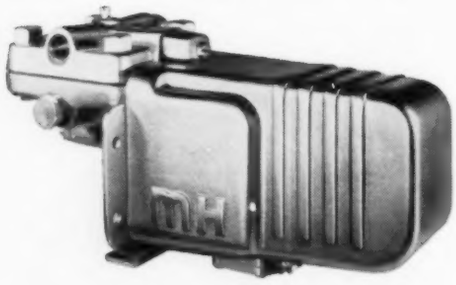
Instrumentation for every furnace . . . every fuel

Flow of viscous fluids such as Bunker C oil, tar and pitch is measured by this Area Meter. Linear electrical signal is transmitted for remote indicating, recording, controlling or totalizing.

Air or gas flow is metered by this bell type meter body, which transmits electrically to remote instruments on the control panel.



For graphic or centralized control, *Tel-O-Set* miniature indicators, recorders and controllers save panel space . . . provide accurate, flexible instrumentation for temperatures, flows, pressures.



Differential Converter mercuryless pneumatic transmitter can be used for steam, air or gas flow measurement. Rugged and sensitive, it is easily calibrated in the field.

Metered Fuel-Air Ratio Control *saves fuel dollars*

Fully automatic systems cut costs on single, alternate, or combined fuel-fired installations

HONEYWELL metered fuel-air ratio control systems on your furnaces will get the maximum Btu's from available fuel. Moreover, in addition to saving fuel dollars, these systems are designed for operating convenience.

For example, an operator can check firing conditions by merely glancing at the large, easily-read charts and scales on the *ElectroniK* controllers. With the turn of a knob, he can set up automatic Btu input control, or switch over to manual control for startup or emergency operation.

Honeywell metered fuel-air ratio control systems are, fundamentally, fuel savers, and are applicable to gas, oil, tar, pitch, air, or steam flow measurement and control. They provide direct and immediate indication of set points and ratio settings. Where panel space is limited or where graphic centralized panel operation is desirable, Honeywell miniature *Tel-O-Set* instruments can be supplied in these systems.

Each system is individually engineered to your specific furnace and fuel requirements. For a discussion of what Honeywell metered fuel-air ratio systems can do for you, call your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA:** Write for Data Sheets No. 4.3-4a, "Fuel-Air Ratio Control Systems"—and No. 6.4-12, "*ElectroniK* Inductance Bridge Receivers."

H HONEYWELL

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

Whatever your needs in clean air

1 General plant ventilation.

2 Protection of product quality.

3 Cooling of electrical equipment.

4 Protection of product finishes.

5 Protection against fumes and oil mist.

AAF has the equipment to do the job

1 Electronic precipitators.

2 Dry-type filters.

3 Viscous filters.

With the maintenance characteristics you want

1 Filters that are automatic, self-cleaning.

2 Filters that feature renewable media.

3 Filters that are reconditioned by washing.

4 Filters that are thrown away when soiled.

AAF herman nelson

American Air Filter
COMPANY, INC.

302 Central Avenue, Louisville 8, Kentucky
American Air Filter of Canada, Ltd., Montreal, P. Q.

Herman Nelson Unit Blowers

Herman Nelson Propeller Fans

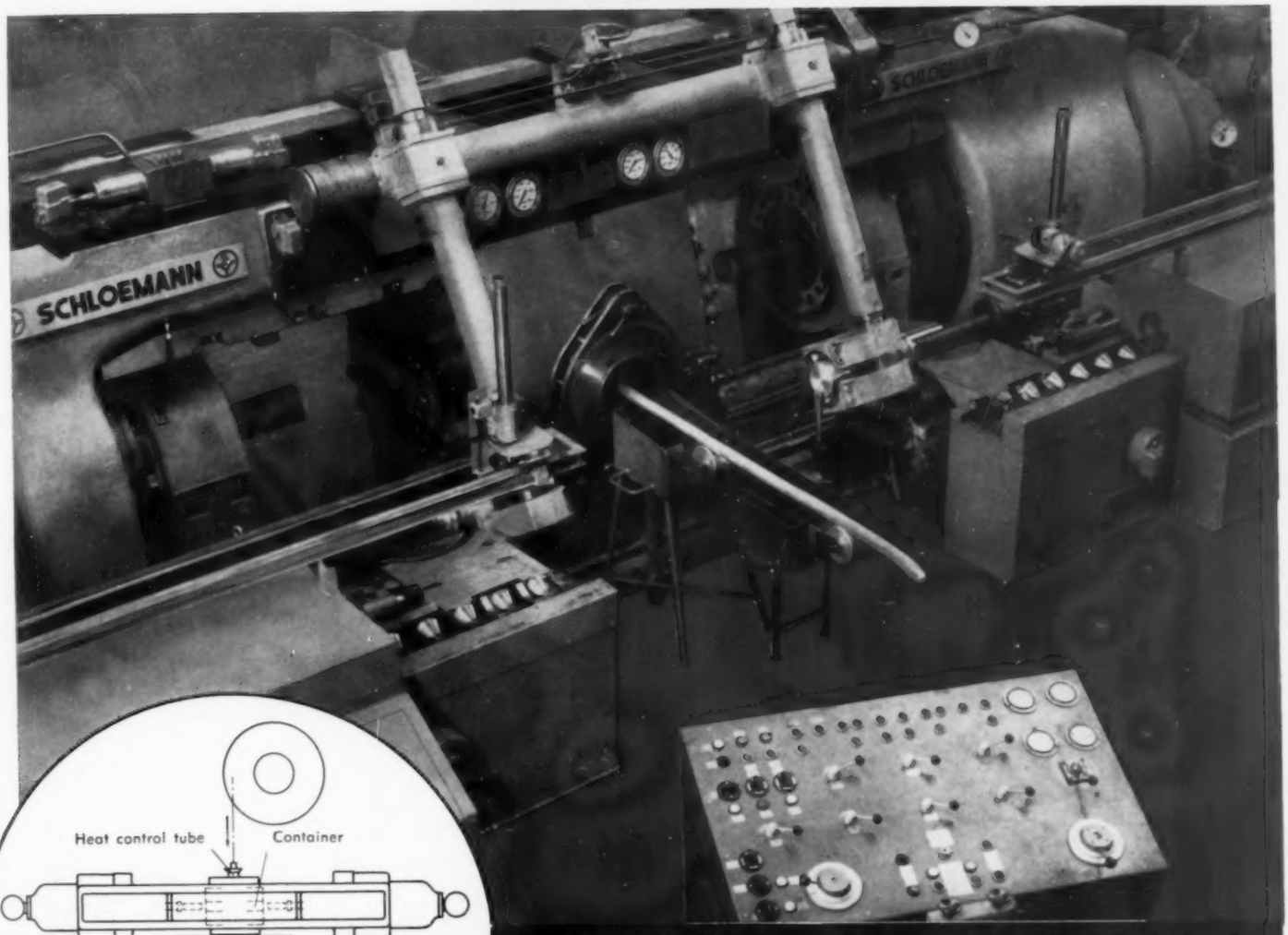
— BETTER AIR IS OUR BUSINESS —

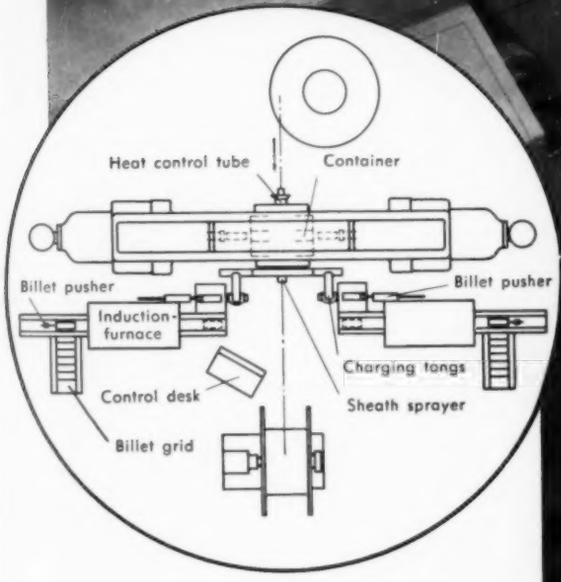
Illinois Heating Specialties

Air Filters and Precipitators

SCHLOEMANN

Aluminum Cable Sheathing Press





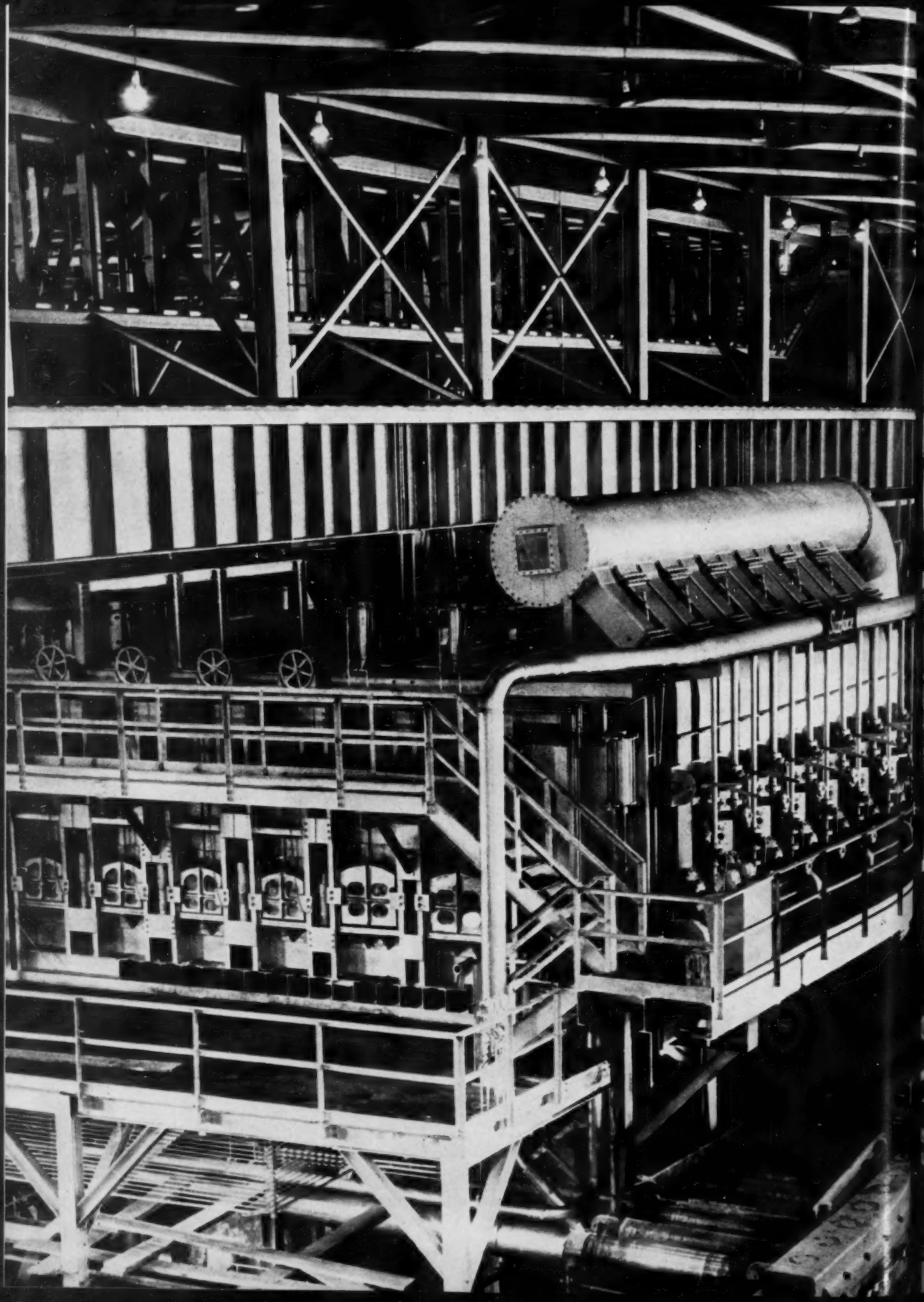
This 1760 ton unit, FIRST of several to be erected in the United States, is now being installed at a plant of GENERAL CABLE CORPORATION.

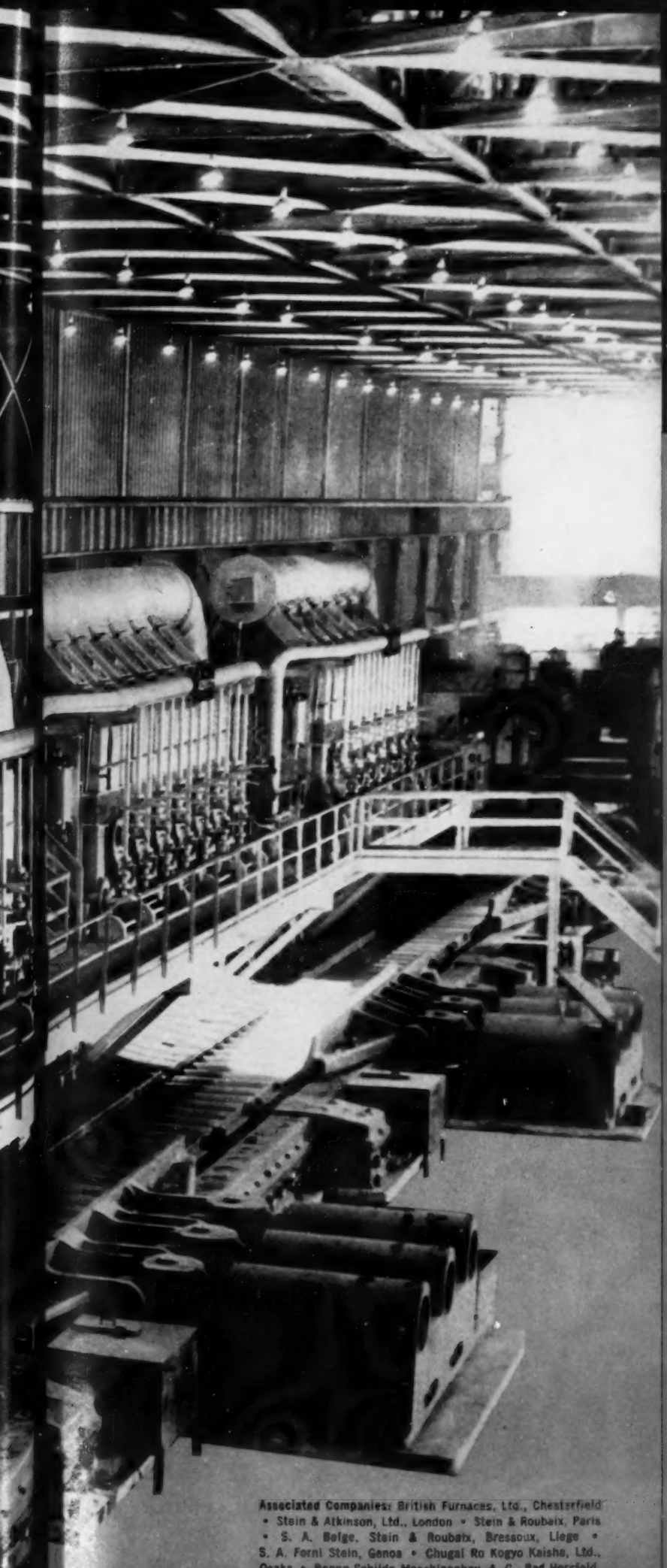
Unique advantages may be attained with this small unit

Cable of any desired length can be sheathed, up to 2 3/8 in. or 4 in. o. d. respectively · High efficiency, as two solid billets are extruded against each other with low power requirements · Direct self-contained oil-hydraulic pump drive for the extrusion, combined with accumulator for shortening the dead periods · Simple and quick automatic operational sequence · Smooth, perfectly welded cable sheaths with a uniform grain structure · Effective heat protection of the cable core insulation · Economical production even of very thin-walled tubes, and of sections and wire

FELLER ENGINEERING COMPANY 1159 Empire Building, Pittsburgh 22, Pa.

HOT AND COLD ROLLING MILLS • COUNTERBLOW HAMMERS • HYDRAULIC PRESSES





Associated Companies: British Furnaces, Ltd., Chesterfield • Stein & Atkinson, Ltd., London • Stein & Roubaix, Paris • S. A. Belge, Stein & Roubaix, Bressoux, Liege • S. A. Forni Stein, Genoa • Chugai Ro Kogyo Kaisha, Ltd., Osaka • Benno Schilde Maschinenbau, A. G., Bad Hersfeld.

200 TONS AN HOUR CONTINUOUSLY

200 tons of steel slabs are heated to rolling temperature every hour, continuously, in each of these Surface monsters—world's largest slab furnaces.

No other furnace today can list all of these features:

1 Cantilever skid supports* permitting unobstructed combustion space for underfiring.

2 Furnace lines and burner design which provide high heat input from the moment the slab enters the furnace.

3 Built-in control* to prevent intermingling of gases from upper and bottom zones, providing better control of heat application, and preventing overheated slab end.

4 Anticipatory control which reduces temperature head when rate of slab discharge decreases.

5 Air preheat up to 1100°F.

6 Television signal to pusher pulpit, informing operator of the exact position of the leading slab.

About the only conventional feature in these giants is the fact that the slabs are pushed in one end and out the other.

This is another demonstration that, at Surface, unconventional thinking and conventional experience are a productive team for the steel industry. Surface Combustion Corporation, Toledo 1, Ohio.

*patents pending

Surface
STEEL MILL EQUIPMENT

If you are ever going to need an

OVERHEAD CRANE . . .

you need this book, now!

Before you take the first step in planning your next overhead-crane purchase, you owe it to yourself and your firm to protect that "big-ticket" *lifetime* investment by reading this booklet, "How to Evaluate Crane Bids." Don't wait until the specifications are drawn up. Accurate guidance from the first planning stages will help insure the best return from your crane investment.

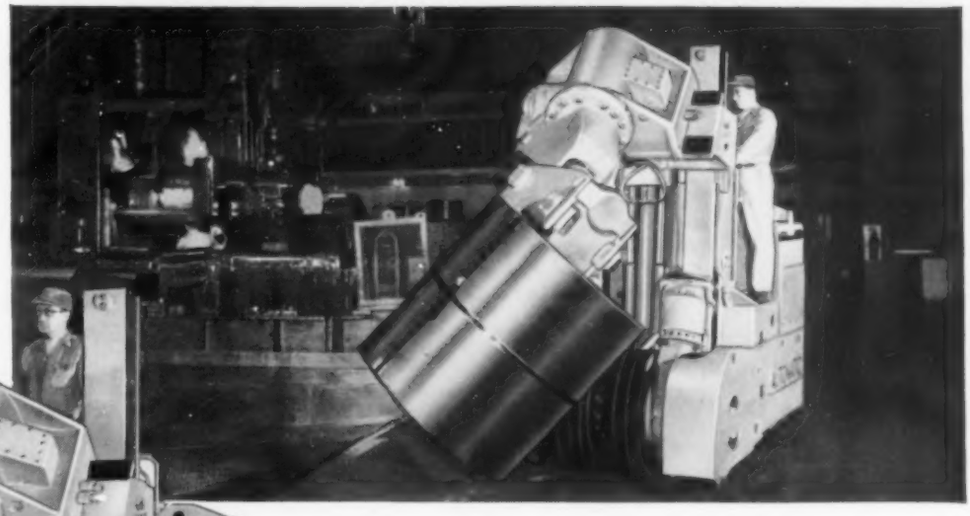
Harnischfeger, leader in overhead cranes, offers an unmatched source of background and experience in helping you choose a crane installation — with no obligation, of course. P&H have pioneered every major crane advancement . . . including Magnetorque, for precision control, and now the new Electronic "stepless" crane control for the ultimate in smooth, precise performance.

Send for this free booklet, now. Write Dept. 101G Industrial Division, Harnischfeger Corp., Milwaukee 46, Wisconsin.

New Automatic Attachment is COIL UP-ENDER AND RAM IN ONE!

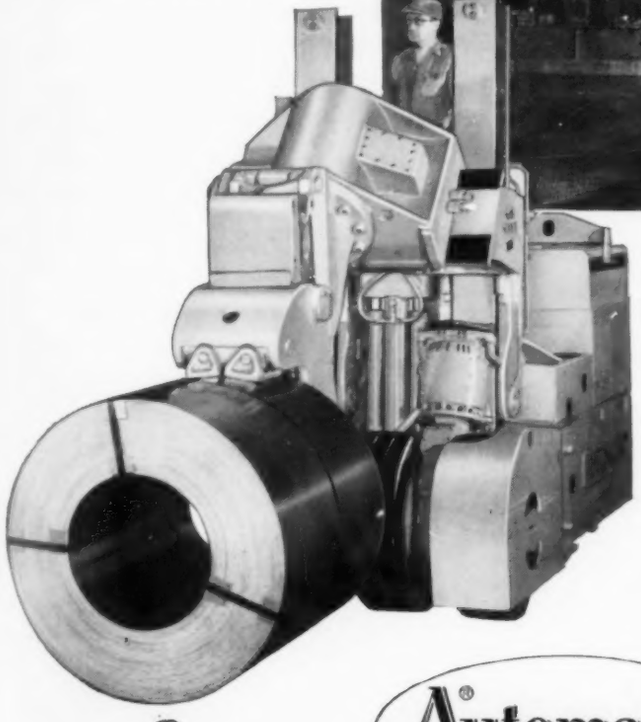
1.

Picks up coil in vertical position and rotates to horizontal or vice versa... handles up to 60,000 lb. coil.



2.

Holds coil securely throughout rotation...prevents telescoping...no distortion, no damage to coil ends.



3.

Transports coil in any position; can be replaced by forks or ram for other uses.

Only Automatic Has It!

Another important "first" for Automatic engineering...this attachment eliminates the necessity for separate up-ending units in handling steel coils weighing up to 60,000 lbs. Flexibility in handling and storage is substantially improved and usefulness of the heavy duty ram truck is correspondingly increased. The coil is held securely, at any stage of rotation with a minimum of pressure, eliminating damage to coils.

This unit is now available on the new Automatic HR Series electric trucks or as an attachment for any Automatic truck of suitable design and capacity. Write today for further information.

Automatic
47 West 87th Street
Chicago 20, Illinois, Dept. B-7

WORLD'S LARGEST EXCLUSIVE BUILDER OF ELECTRIC-DRIVEN INDUSTRIAL TRUCKS

a few of the many types of
SPRAYING SYSTEMS CO.

spray nozzles

. . . for such operations as roll cooling on hot and cold mills • descaling • runout table cooling • pickling line • cooling slabs on transfer table • cooling ingot molds • cooling open hearth tunnels or checkers • cooling pigs • coke chemical processing • spraying lubricants • and air and gas washing

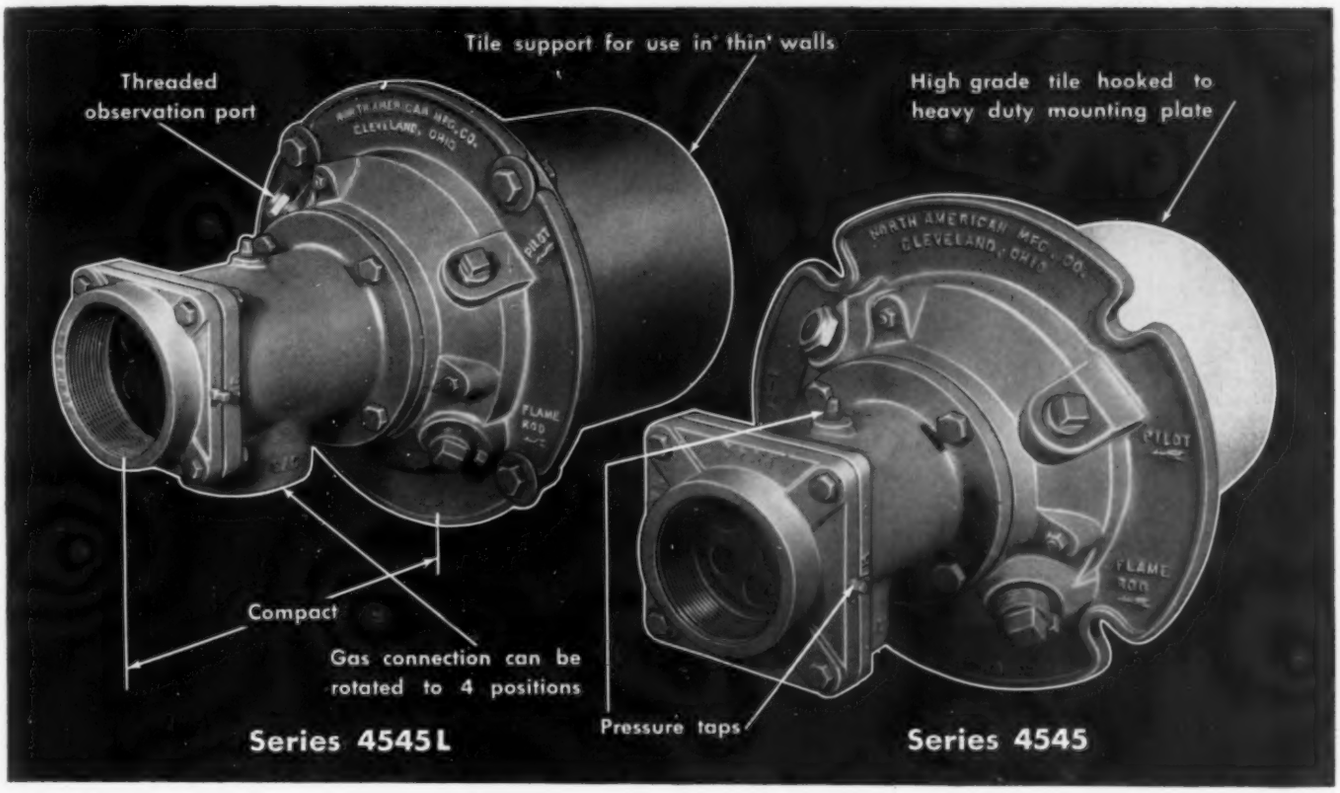
For every spraying operation, you will find Spraying Systems spray nozzles offer impressive, measurable advantages. That is why so many mills today specify Spraying Systems spray nozzles for every application. Made in a very wide range of types and sizes to provide exact performance to meet your requirements. To improve operations where spraying is involved, try Spraying Systems spray nozzles . . . . the engineered products of America's leading designer and manufacturer of spray nozzles for industry. Your inquiry is cordially invited.

SPRAYING SYSTEMS CO.
3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

Write for your FREE copy of new Catalog No. 24 . . . the most comprehensive spray nozzle catalog ever produced.

Penetrating Heat

by North American


Tile support for use in thin walls
Threaded observation port
High grade tile hooked to heavy duty mounting plate
Compact
Gas connection can be rotated to 4 positions
Pressure taps
Series 4545L
Series 4545

Nozzle-Mixing Gas Burners

High velocity central jet gives deep penetration
Sealed-in for complete atmosphere control

Provision for flame safety with ignition pilot

5 Sizes — 3″ to 8″ — 1.5 to 12.4 million Btu/hr

3′ to 8½′ flame length with 1 psi air

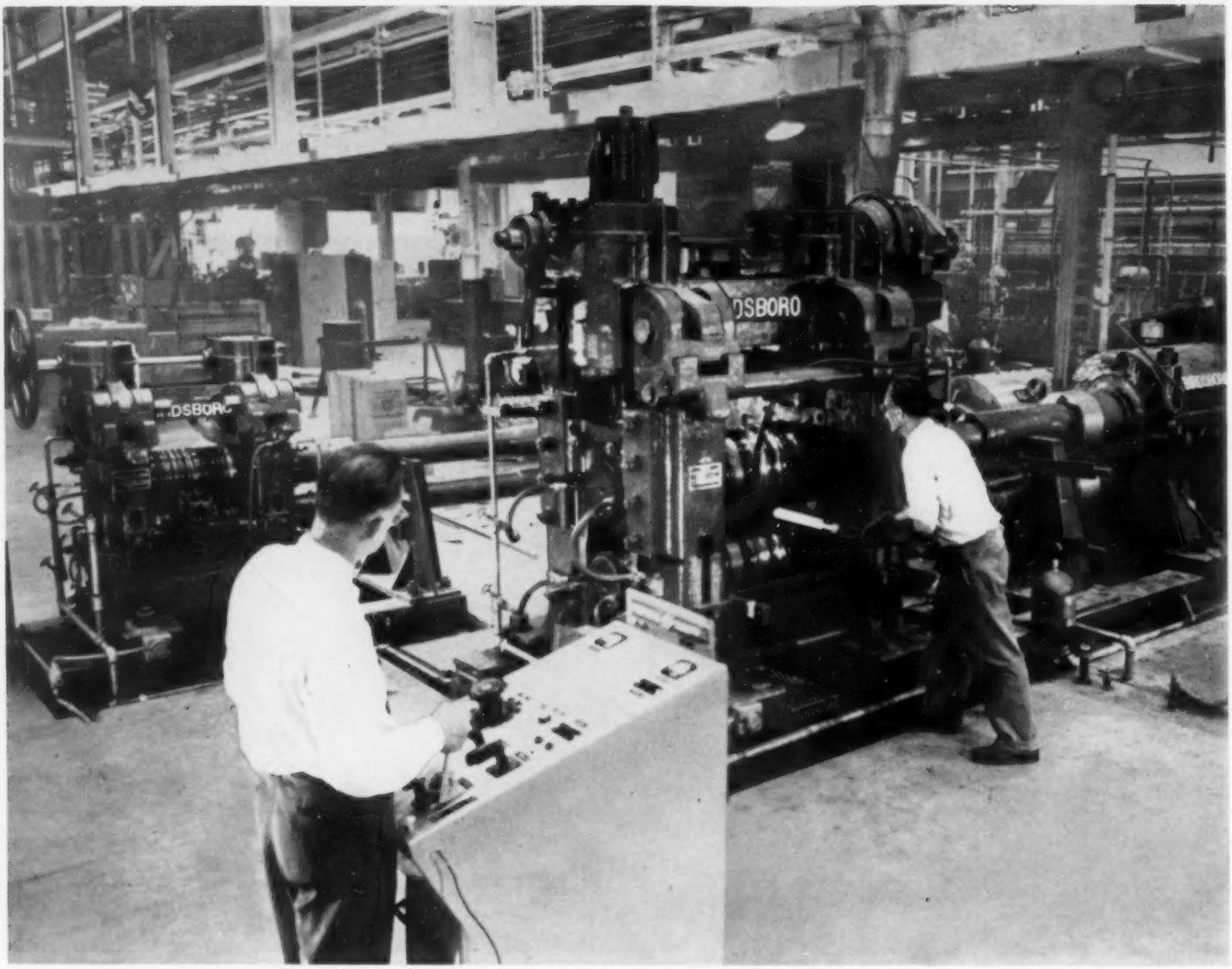
for additional information consult your local n. a. engineer or write for bulletin 4545

NORTH AMERICAN COMBUSTION since 1917

the **NORTH AMERICAN** mfg co

Combustion Engineers

4455 East 71st St. • Cleveland 5, Ohio



General Electric explores new areas with experimental mill by BIRDSBORO

● New metals are coming on the market, but only through experimentation can their capabilities be determined. In Schenectady, N.Y., General Electric has installed in its new laboratory a Birdsboro 16″-10″ bar mill, designed to help scientists seek out the unknown factors of these new metals through experimentation and specialized production.

The mill features 2 stands of different pitch diameter to accommodate the large range of product size required. The 16″ roughing mill includes a motorized screwdown for high speed roll setting when performing slabbing operations. It also permits use of a bull head and grooved passes to get a wide range of product with a minimum of roll changing. Again, Birdsboro has developed a mill that not only sets the pace in design, but through expert utilization by General Electric will help in opening new fields in metals production. When extraordinary results are desired, more and more companies turn to Birdsboro . . . and it pays! For more details of Birdsboro leadership in customized mill machinery, write to:

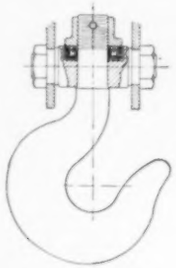
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
District Office: Pittsburgh, Pa.
Engineering Subsidiary: Engineering Supervision Co.
120 W. 42nd St., New York 36, N.Y.

MM56-94

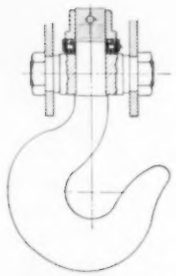
BIRDSBORO
STEEL FOUNDRY AND MACHINE CO.

STEEL MILL MACHINERY • HYDRAULIC PRESSES (Metalworking and Extrusion) • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS • "CAST-WELD" Design • ROLLS: Steel, Alloy Iron, Alloy Steel

New bulletin shows latest R.B.E.C.* tables for crane hook bearings . . .



Rollway Type CT Crane Hook Thrust Bearing



Rollway Type WCT Crane Hook Thrust Bearing

Reflecting the newest standards for the selection of crane hook bearings, the tables contained in this Rollway bulletin are founded on *basic static load ratings.*

This approach takes into account the ability of Rollway-built rollers and plates to recover from temporary deformation due to static loading, as soon as the bearing starts to rotate.

Actual bearing capacities of Rollway Crane Hook Bearings are *higher* than those given in the tables, because in most crane-hook applications the bearing is operating under slow speed conditions.

Crowned Rollers Provide Even Load Distribution

The crowned rollers used in Rollway Crane Hook Bearings eliminate the harmful effects of corner loading of rollers. Weight is distributed evenly along the full line of contact between roller and plate. Starting torque is reduced by as much as 25% as compared to straight rollers!

* Roller Bearing Engineers' Committee of the Anti-Friction Bearing Manufacturers' Association

Rollube Retainer Resists Wear

All Rollway Crane Hook Bearings feature the new Rollube Retainer, made of ferrous material with corrosion resistant finish. Wear properties are excellent even under adverse lubricant conditions.

• For full information on the R.B.E.C. tables and Rollway Crane Hook Bearings, send coupon below.

ROLLWAY®
BEARINGS
COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ROLLWAY BEARING CO., INC.
569 Seymour St., Syracuse, N. Y.
Please send your "Crane Hook" Bulletin No. 956.

Name ..... Title .....
Firm Name .....
Address .....
City ..... Zone .... State .....

ENGINEERING OFFICES: SYRACUSE • BOSTON • CHICAGO • DETROIT • TORONTO • PITTSBURGH • CLEVELAND • MILWAUKEE • SEATTLE • HOUSTON • PHILADELPHIA • LOS ANGELES • SAN FRANCISCO

Photos Courtesy of
GREAT LAKES STEEL CORPORATION
(Division of National Steel Corporation)
ECORSE, DETROIT 29, MICHIGAN.

. . . they're "FACTORY MOLDED" as one-piece Neoprene/rubber units!

Can you think of a more demanding environment for electrical connectors . . . than the water-soaked, run-out motor installation pictured above? If you can, odds favor a bet that JOY connectors are "at work" there, too! For in all those qualities that add up to a long life of dependable, maintenance-free performance, JOY electrical connectors excel.

Factory molded as one-piece Neoprene jacketed units, *that resist impact damage like a rubber ball, and are practically immune to the aging effects of oils, acids, alkalines and sunlight . . .* JOY electrical connectors are rapidly becoming Industry's favorites for portable power and control circuits. When connected, close-fitting face sections provide "cork-like" seals around engaged contacts, protecting them from moisture, metallic dust and other airborne particles that are so damaging to an electrical connector's performance.

Want specific information on JOY connectors for your electrical circuits? Describe your needs and we'll mail it promptly! You'll be glad to have this information handy, next time you need good electrical connectors.

Use them with . . .

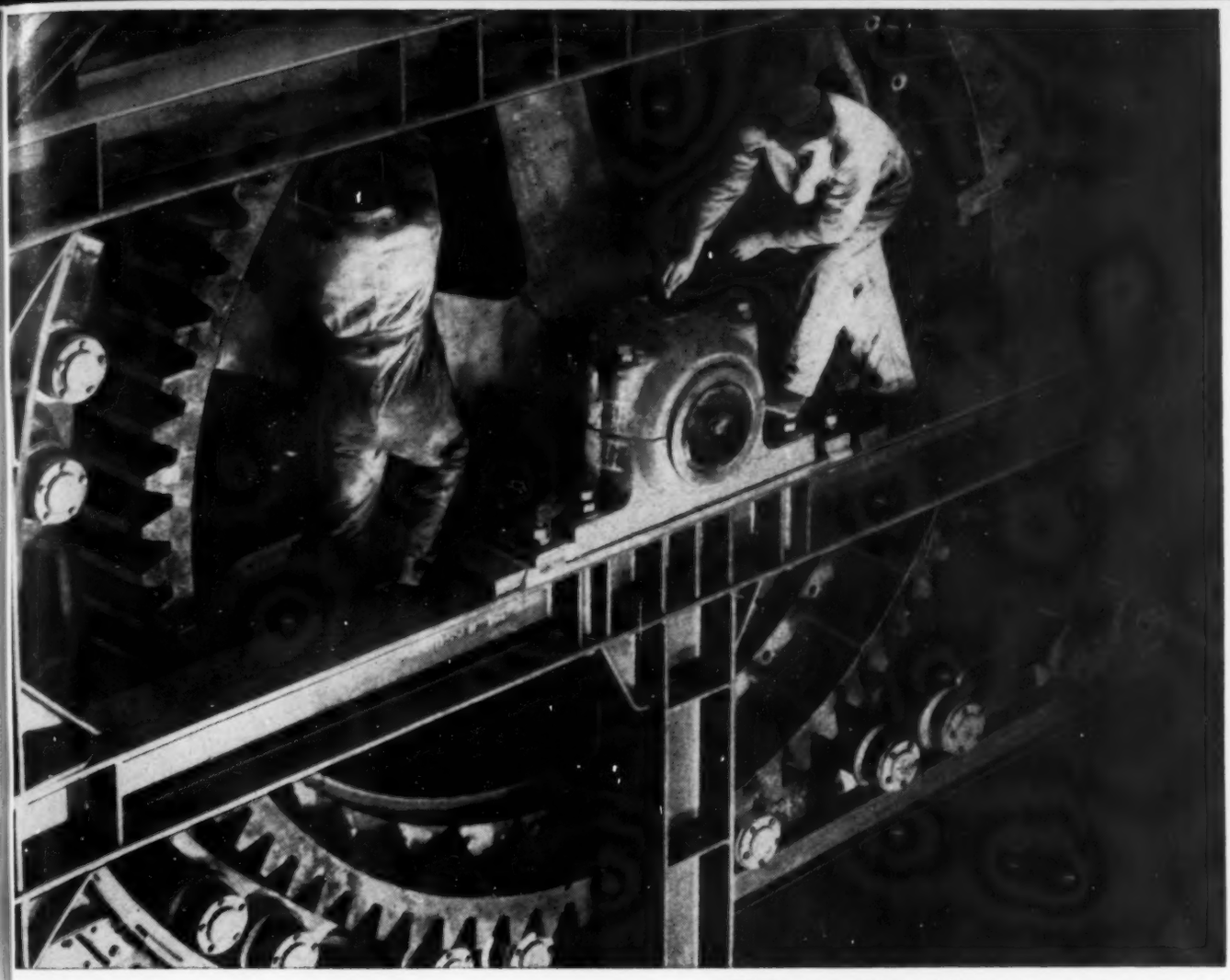
- RUN-OUT TABLE MOTORS
- ELECTRO-MAGNET FEEDERS
- WELDING WHIPS & CABLE
- MAN-COOLING FANS
- MOTOR CONTROL CIRCUITS
- COILING MOTOR FEEDERS
- TRANSFER CAR FEEDERS
- CONVEYOR CIRCUITS
- SAND-SLINGER CABLE
- POWER LINES TO LADLES

YOURS . . . ASK FOR IT!

BULLETIN B41 — An attractive, three-color bulletin that illustrates and describes JOY electrical connectors for Steel Mills, Foundries, and other heavy industrial needs.

CD 1156.1

JOY MANUFACTURING COMPANY
ELECTRICAL PRODUCTS DIVISION
1201 MACKLIND AVE., ST. LOUIS 10, MO.
EXECUTIVE OFFICES, HENRY W. OLIVER BLDG., PITTSBURGH 22, PA.



Sinter machine drive gear and sprocket

DRAVO-LURGI

45 years of sintering machinery design experience

During the past 45 years, Lurgi has made over 250 sintering plant installations to qualify as Europe's foremost designer of all types of equipment for the treatment of low grade ore. And over a similar period, Dravo has been designing and fabricating special-purpose and heavy duty equipment.

An exclusive license agreement combines Lurgi design experience with Dravo's extensive engineering and construction facilities to provide sintering equipment adapted to the needs of American industry. Dravo is presently engaged in constructing a number of iron ore sintering plants which will have an aggregate annual capacity of over 11,000,000 tons.

Engineering and planning assistance is available to help you develop equipment or complete plants for sintering, pelletizing or other related ore processing and preparation. Write to Dravo Corporation, Dept. S-100, Pittsburgh 22, Pa.

DRAVO
CORPORATION

Blast furnace blowers · boiler & power plants · bridge sub-structures · cab conditioners · docks & unloaders · dredging · fabricated piping

foundations · gantry & floating cranes · gas & oil pumping stations · locks and dams · ore & coal bridges · process equipment · pumphouses & intakes

river sand and gravel · sintering plants · slopes, shafts, tunnels · space heaters · steel grating · towboats, barges, river transportation

from start to finish

Gears, track wheels, sheaves on ore bric[k] [s]haves, [c]

Gears, track and brake wheels, sheaves, axles, shafts, racks, on soaking pit cranes.

Screwdown screws, table gears, liner plates, manipulator gears and slides, on 46" blooming mill.

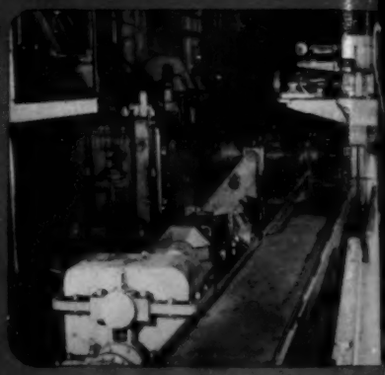
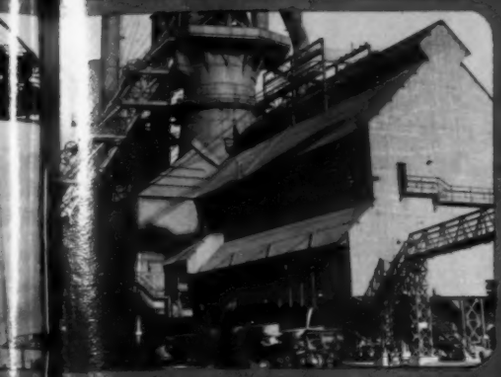


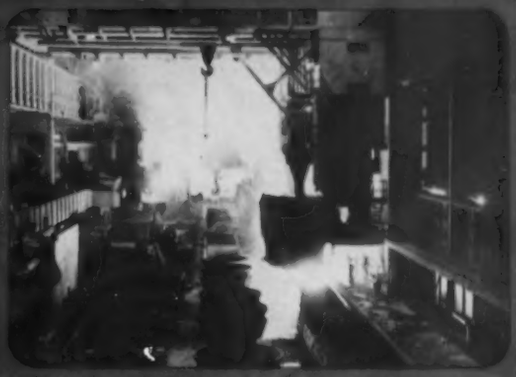
Table gears on new wide flange beam m[ill]

it's TSP at[l]



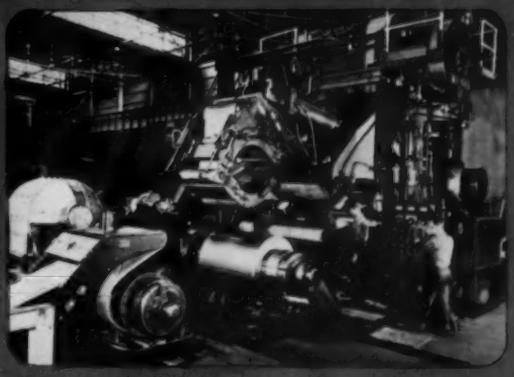
...aves, wheels, mud-gun screws and nuts on blast furnace equipment.

Gears, pinions, wheels on coke making equipment.



Gears, track and brake wheels, sheaves, axles, shafts, on open hearth equipment.

Table gears, crane gears and pinions, shafts, axles, brake and track wheels, on continuous hot strip mill equipment.



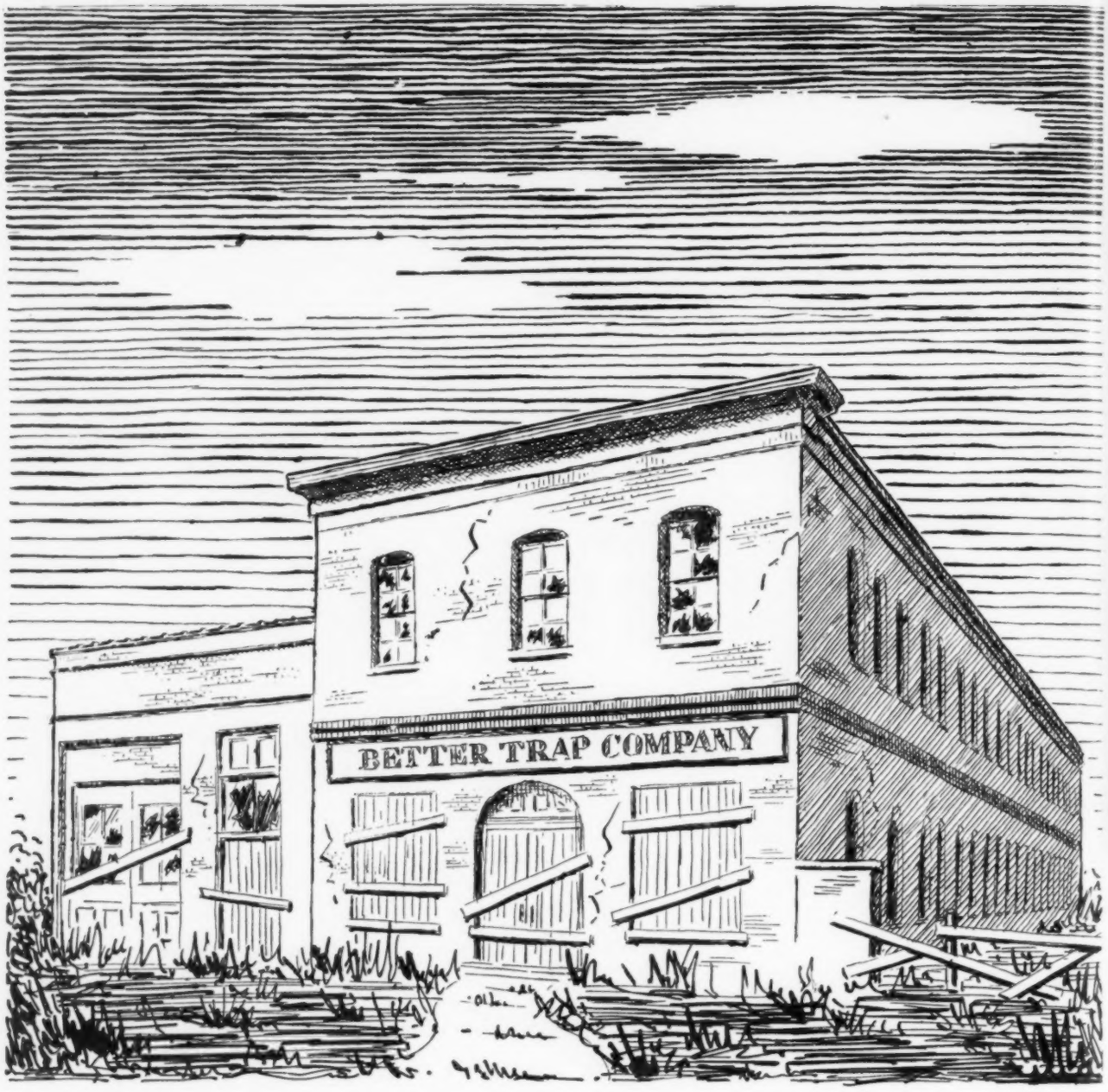
Work rolls, leveller rolls, pinch rolls, gears, pinions, racks, on cold strip mill equipment.

Table gearing on bar mill and hot bed tables run-out.

...INLAND since 1911

THE TOOL STEEL GEAR AND PINION CO.

CINCINNATI 16, OHIO, U. S. A.



MOUSETRAP STEAM TRAP, SEWER TRAP

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. . . the world *won't* beat a path to the door of the man who builds a better one *and then doesn't advertise it* so that people will know about his product, know where it can be bought and how much it costs.

Advertising benefits the buyer, too. It tells you the product story, makes it easy for you to buy. Even more important to you, advertising leads to mass production and volume sales . . . which means lower costs and lower prices.

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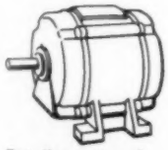
NEW Elliott C-W type N Motor PERMANENTLY SEALED Against Dust, Moisture, Corrosive Fumes

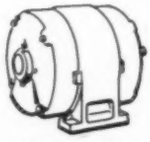
The rugged "Sealedpower" cast frame Elliott motor shown above is the modern version of the design pioneered in this country by Crocker-Wheeler. An external fan, made of sparkless material, and surrounded by a cowl, blows air along the frame for highest cooling efficiency. An internal fan provides continuous air circulation within the enclosure. All openings in the frame are tightly sealed, providing complete protection to windings and working parts.

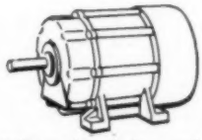
Once applied only in locations where extremely destructive atmospheric conditions prevail, totally-enclosed motors are today rapidly gaining acceptance for all types of applications. Users find that the total over-all cost—first cost plus maintenance—is less than that of open or semi-enclosed motors.

Ask your Elliott representative for details, or write for the new type N motor bulletin. Address Elliott Company, Crocker-Wheeler Division, Jeannette, Pennsylvania.

OTHER C-W TYPE N MOTOR ENCLOSURES


Totally-enclosed non-ventilated


Dripproof Protected


Totally-enclosed, fan-cooled Frames 256 U and smaller

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We will be glad to send a copy of this new booklet describing the complete line of Elliott C-W type N motors. Please write on company letterhead.

W6-6

1957

New

Link-Type HINGE ALIGNMENT DEVICE

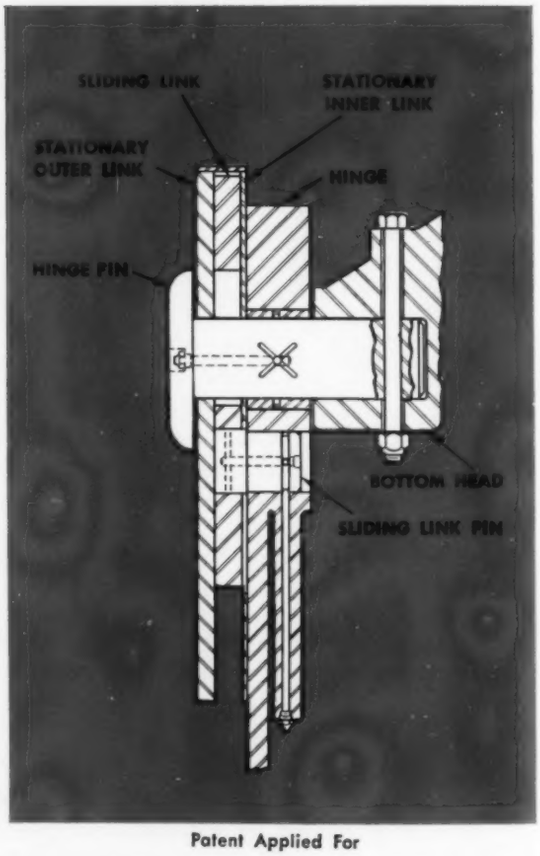
available on Mead-Morrison Grab Buckets

...eliminates hinge gears

When non-crushable material gets caught in a conventional grab bucket gear-type alignment device, it means trouble . . . jammed and broken teeth.

The exclusive link-type hinge alignment device developed by Mead-Morrison *eliminates* this trouble. It operates by the interaction of a linkage of steel plates instead of the vulnerable gear teeth of conventional alignment devices. The mechanism is fabricated entirely of high tensile alloy steel. In addition, it has a much larger bearing surface than the ordinary gear-tooth construction, is entirely enclosed and easily lubricated. The result . . . less lubrication problem . . . less maintenance expense.

Write for complete information.



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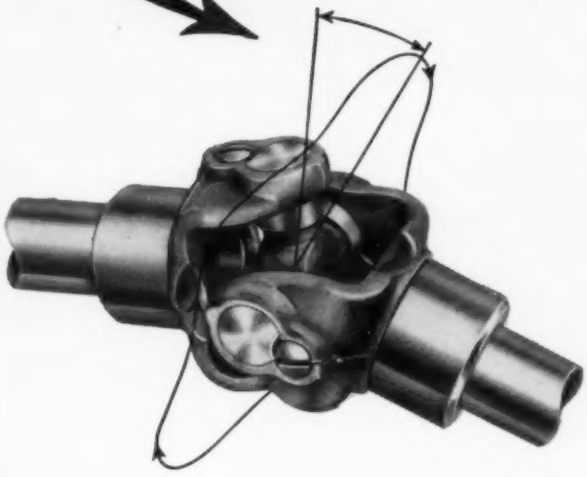
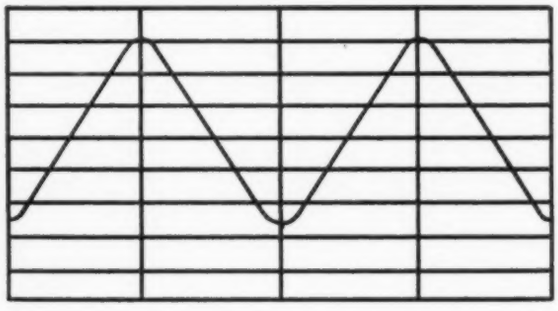
Division of McKIERNAN-TERRY CORPORATION

HARRISON, NEW JERSEY

MK823

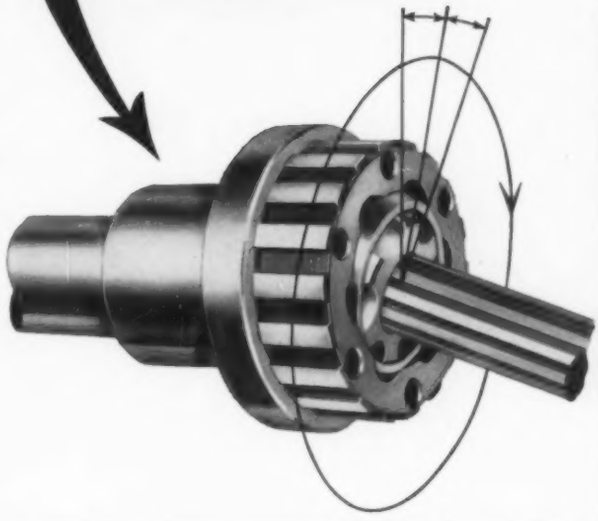
This Action Costs You Money

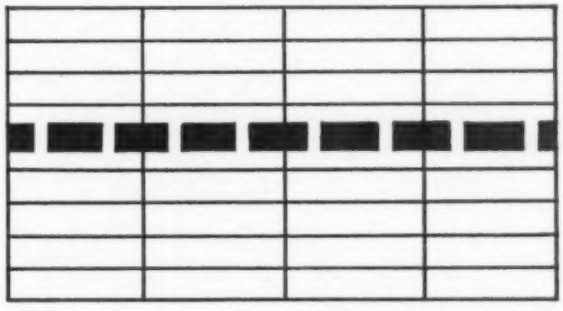




During rotation at a given angle, pin or slipper-type joints speed up, slow down twice during one revolution, as shown by the solid line in the graph.

This Action Saves You Money





Rzeppa Joints *always* transmit torque smoothly, even at unbalanced angles. Note constant velocity of 100% for Rzeppa Joint (dotted line).

Are You Getting The Most Out Of Your Rolling Equipment?

The simple illustration above shows how Rzeppa Constant Velocity Joints transmit torques smoothly—and profitably—on many of today's most advanced mills.

Steel-producing equipment of all types can take advantage of Rzeppa's unique design. It makes possible these money-saving features:

- INCREASED SPEEDS
- REDUCED DOWN-TIME
- LOWER MAINTENANCE
- GREATER ANGLES

Why not investigate? Write today for descriptive literature.

RZEPPA "SHEPPA" CONSTANT VELOCITY UNIVERSAL JOINTS

THE GEAR GRINDING MACHINE COMPANY

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Manufacturers of: Fully Automatic Gear Grinding Machines • Detroit Screwmatic 750 single spindle screw machine.

What's the best way

LINK-BELT conveying systems provide the answers to more production, less waste, improved safety and working conditions

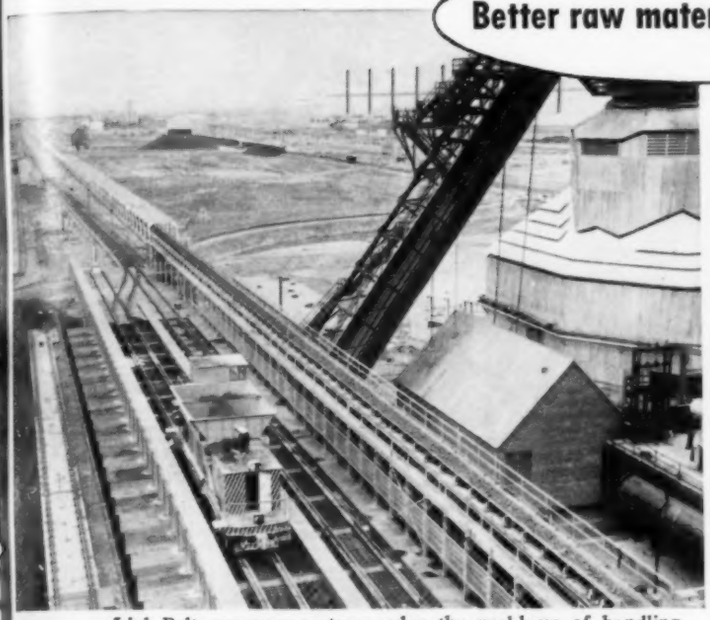
Overall efficiency involving every phase of steel production—from raw materials to finished product — is assured with Link-Belt's modern materials handling equipment. Link-Belt can supply complete conveying systems — designed to increase capacity, cut costs and reduce waste — for bulk materials, coils or any other form of steel.

Link-Belt's engineers will work with your engineers, consultants and builders of mill and process equipment to help you achieve these benefits in your mill. Just call or write your nearest Link-Belt district office.

This important Detroit steel mill greatly increased its cold rolled steel capacity — with no appreciable addition in floor space — by installing three Link-Belt conveyors. Much larger coils are now handled easily with less scrap loss and less idle mill time.

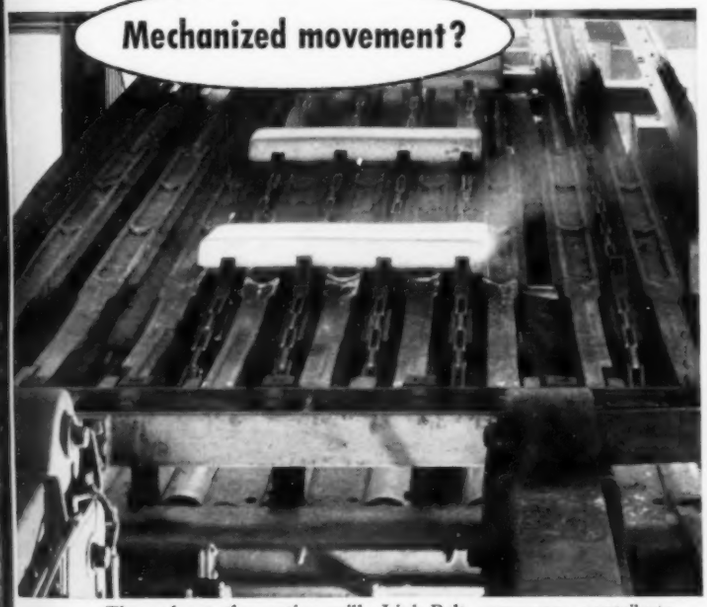
to boost your output?

Better raw materials handling?



Link-Belt conveyor systems solve the problems of handling and storing various ores, coke, stone, pellets and sinter which are required by the improved techniques of burdening blast furnaces. They are designed to utilize plant space more efficiently in existing mills — fit into the new processes and are suited to the higher capacities of ship unloading and increased production. Regardless of size or physical layout of your mill, Link-Belt can provide a system ideally suited to your conditions.

Mechanized movement?



Throughout the entire mill, Link-Belt conveyors contribute to higher efficiencies and capacities, better space utilization, lower costs and greater safety in the handling of slabs, billets, plates, coils and tubes, as well as raw materials. This conveyor employing Link-Belt steel chain transfers steel billets up incline.

Salvaging waste?

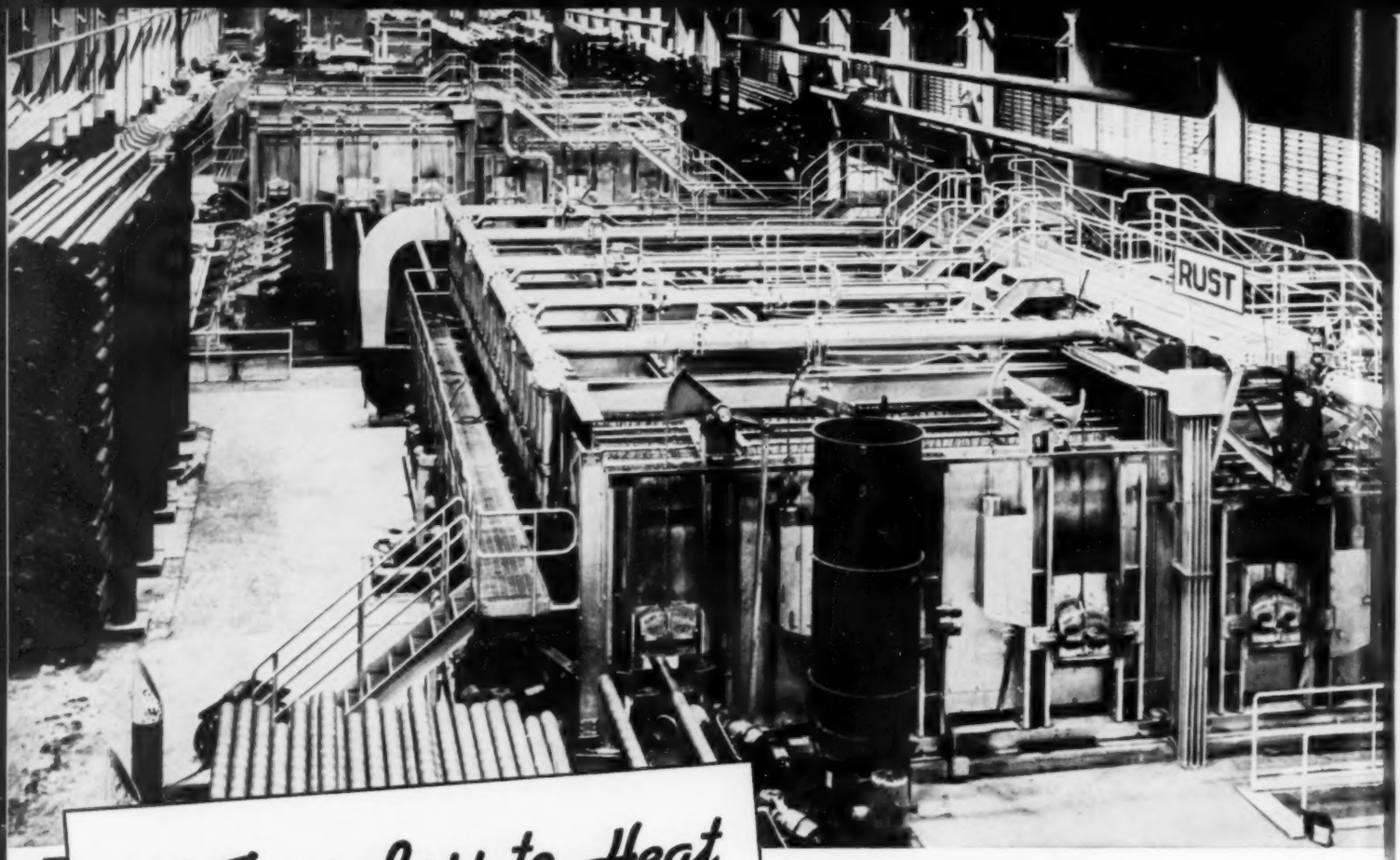
Mill scale recovery was boosted from 250 to 475 tons a week — 72% pure iron — after Link-Belt Straightline Collectors were installed at this mill. In addition, two previous problems (clogged sewers and river pollution) were eliminated. One of five recent L-B installations of this kind.

LINK-BELT

MATERIALS HANDLING, PROCESSING & POWER TRANSMISSION MACHINERY

14,248

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.



116 Tons Less to Heat in this roof

because of B&W Insulating Firebrick suspended construction

Here's another case where light weight means lower cost. The roof of this walking beam furnace is 2,320 square feet. B&W Insulating Firebrick suspended construction for a 9-inch roof weighs about 30 lbs per square foot, including the weight of rods, hangers, pipe, brick and mortar. This is approximately 100 lbs per square foot less than an arch constructed of heavy firebrick plus insulation having the same heat flow. *This saving means the B&W IFB roof is 116 tons lighter.*

The new walking beam furnace (shown in photograph above) was designed and constructed by Rust Furnace Company for Jones & Laughlin Steel Corporation. Seamless pipe is conveyed into the furnace, moves slowly from left to right on walking beam rails designed and furnished by York-Gillespie Mfg. Co., and passes out the exit door.

Here are the money-saving benefits of B&W suspended construction:

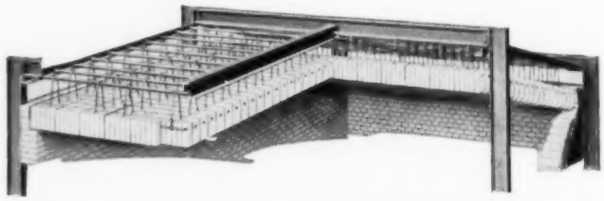
1. Supporting steel is less massive, far less costly. Commercial size steel can be used for roof suspension instead of special castings.

2. B&W Insulating Firebrick heat up and cool down faster. This means lower fuel costs, faster inspection.

3. Furnace temperatures can be changed quickly. When different steels call for different heating schedules, the furnace temperature can be adjusted in minutes instead of hours.

4. Installation costs are lower because these lightweight brick can be handled faster and easier than ordinary heavy firebrick.

For complete information on B&W IFB—the *lightest* weight insulating firebrick, write to B&W today or call your local Refractories Engineer.



This is a cross-sectional drawing of a typical suspended arch arrangement using B&W Insulating Firebrick. It can be used in flat or sloping roofs, nose arches and many other types of suspended furnace construction.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
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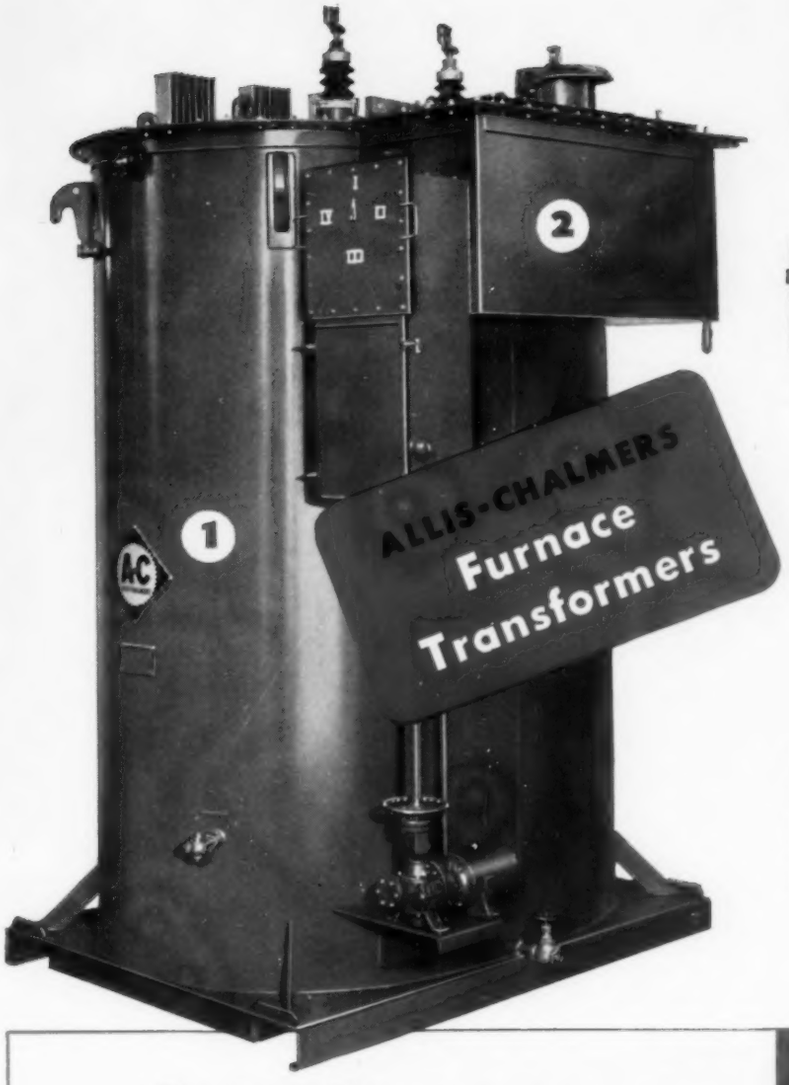


4 Extras for Tough Jobs

Check features based on over 30 years' experience building arc furnace transformers

Features like these help Allis-Chalmers arc furnace transformers stand up under strain of repeated daily short circuits . . . the heat of high continuous currents . . . the corrosive atmosphere of the plant.

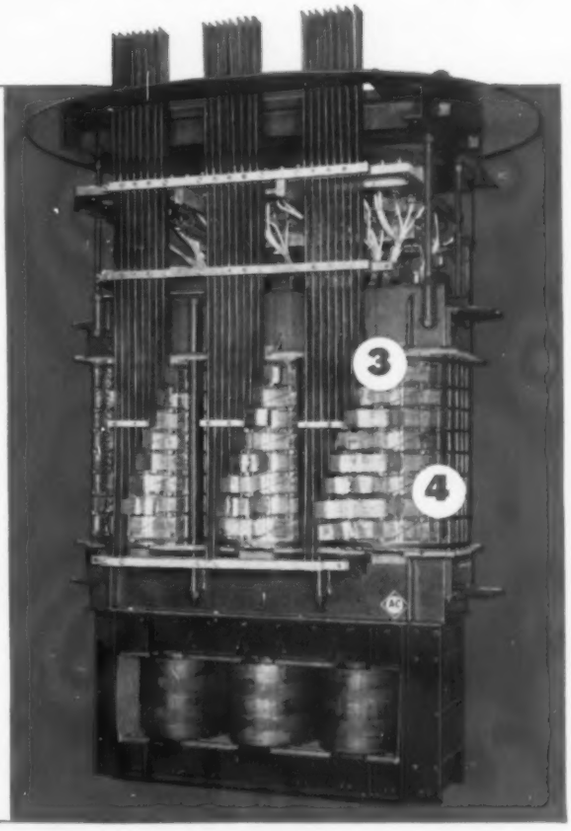
Extra Features —

1 ***EXTRA*** **SURFACE PROTECTION** — Grit blasting and three coats of baked-on alkyd resinous paint guard transformers against industrial corrosion.

2 ***EXTRA*** **ACCESSIBILITY** — Separate compartment for tap changer mechanism facilitates periodic inspection and maintenance.

3 ***EXTRA*** **STRENGTH SUPPORTS** and structure brace coils against severe short-circuit stresses.

4 ***EXTRA*** **PROTECTED WINDINGS** — Special insulation techniques protect winding from overvoltage due to wide tap range.



Complete Line of Arc Furnace Electrical Equipment Allis-Chalmers builds arc and submerged arc furnace transformers of all sizes, plus electrical control, circuit breakers and auxiliary transformers. For help on your problem, call your nearby A-C office or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

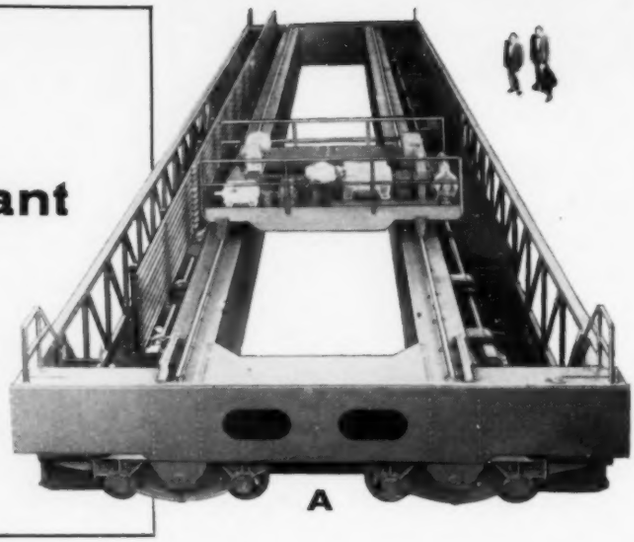
A-C ALLIS-CHALMERS

ALLIS-CHALMERS

LIVE BETTER ELECTRICALLY

A-5086

Get the Crane You Want
. . . turn to
SHAW-BOX



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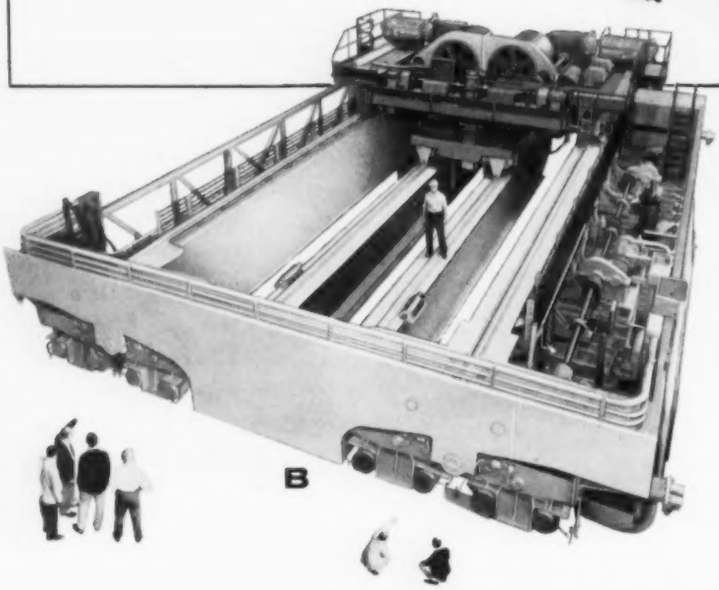
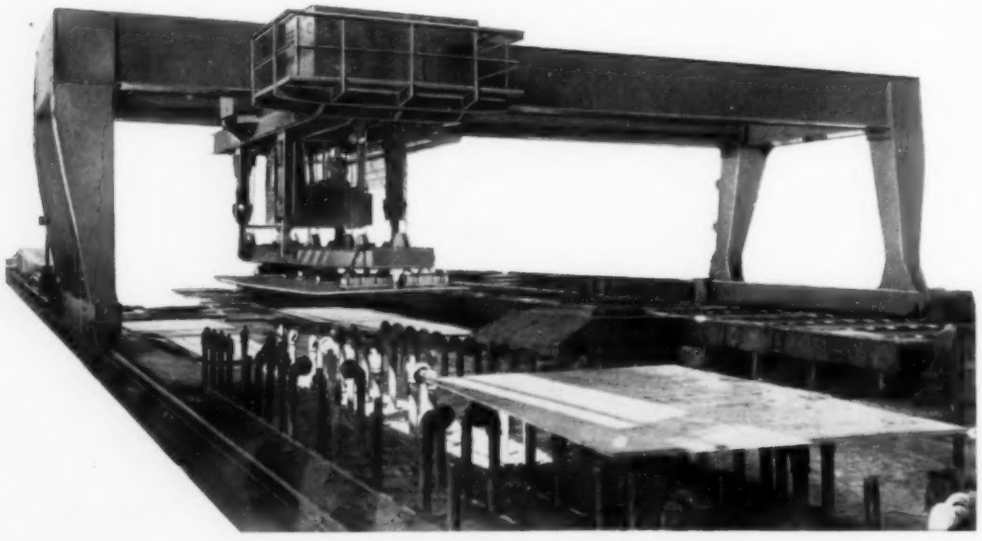


B

"Shaw-Box" Cranes are built exactly to specifications — your own or AISE Standard Specifications No. 6. Whether your plans call for a plate or slab handling crane, a soaking pit carriage, or a ladle crane, the long experience and vast facilities of Shaw-Box can save you time, trouble and money.

Make sure your next mill crane has the strength and rugged construction essential for 'round the clock service — plus economical operation. One of our engineers will gladly discuss specifications and tell you of our standard AISE designs for 15 to 200-ton cranes. Your inquiry is invited.



C

The pictures:
(A) *25-ton, 100-foot span mill crane.* **(B)** *Ladle crane that handles 200 tons of molten steel in 90-ton ladle.* **(C)** *Plate handling gantry with lifting magnets. All have exclusive Shaw-Box structural, mechanical and operational advantages that assure reliable performance.*

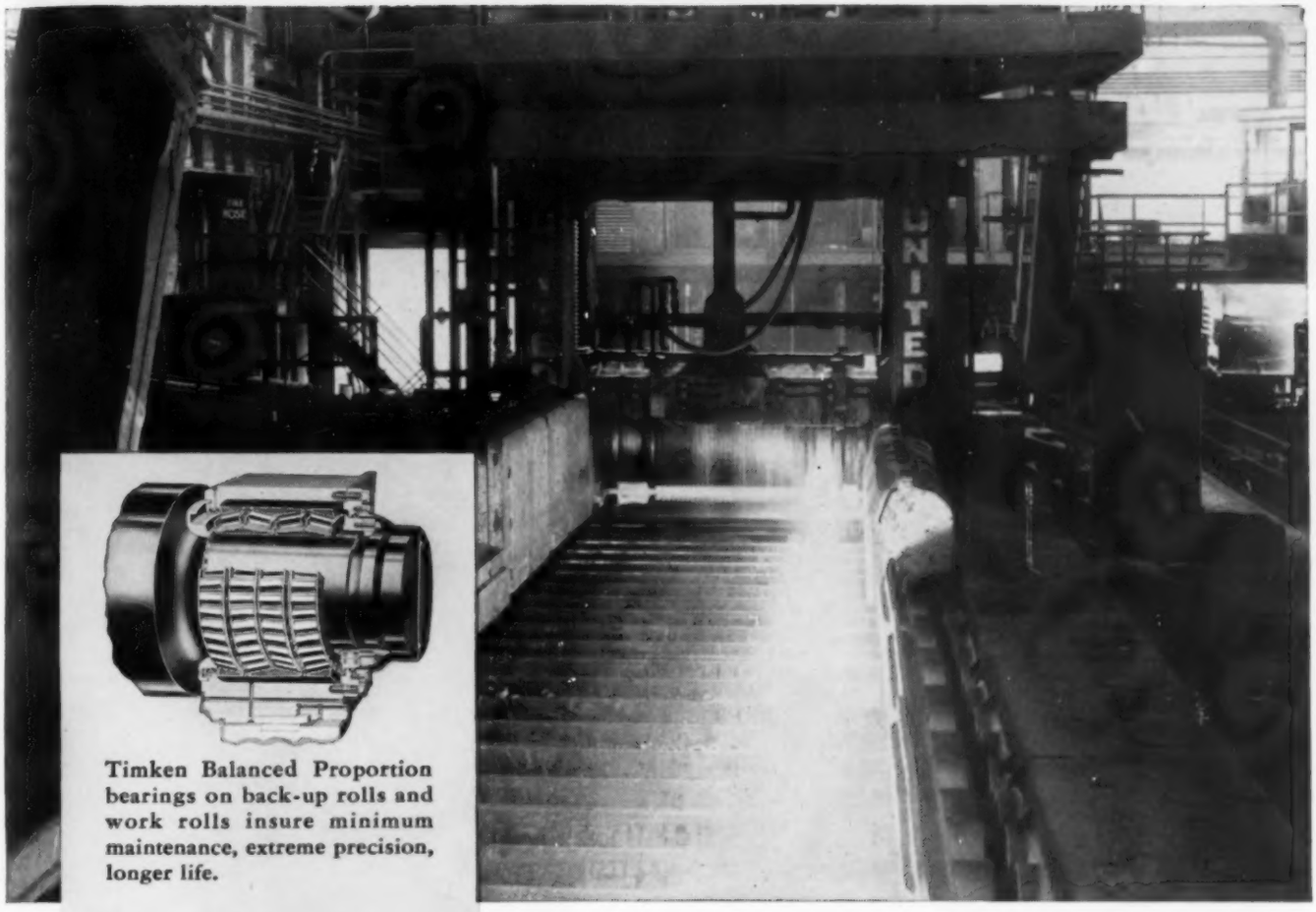
57K-2

"Shaw-Box"® CRANES

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

MANNING, MAXWELL & MOORE, INC.
SHAW-BOX CRANE & HOIST DIVISION
388 West Broadway • Muskegon, Michigan

Builders of "SHAW-BOX" and 'LOAD LIFTER' Cranes, 'BUDGIT' and 'LOAD LIFTER' Hoists and other lifting specialties. Other Divisions produce 'ASHCROFT' Gauges, 'HANCOCK' Valves, 'CONSOLIDATED' Safety and Relief Valves, 'AMERICAN' and 'AMERICAN-MICROSEN' Industrial Instruments, and Aircraft Products.
In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Avenue Road, Galt, Ontario.*



Timken Balanced Proportion bearings on back-up rolls and work rolls insure minimum maintenance, extreme precision, longer life.

2-high bloom and slab mill starts faster, drives easier on TIMKEN® balanced proportion bearings

WITH the roll necks on this 2-high bloom and slab mill—built by United Engineering & Foundry Company for Pittsburgh Steel's Monessen, Pa., plant—mounted on Timken® balanced proportion bearings, friction is practically eliminated. This means lower starting resistance, faster acceleration, easier roll drive and higher rolling speeds. And because the balanced proportion design of Timken bearings permits larger diameter roll necks with no increase in bearing O.D., roll neck strength is increased up to 60%—load ratings up to 40%.

No special thrust bearings are needed; Timken bearings take radial and thrust loads in any combination. And full line contact between the rollers and races of Timken bearings gives them extra load-carrying capacity. Complicated lubrication systems are eliminated, too; Timken bearings permit simple, economical grease lubrication. Rolls can be changed quickly and easily. Wear is greatly reduced, long life is assured. Timken bearings are designed geometrically to *roll true* . . . and are precision-manufactured, under the most rigid quality controls, to conform to their design. Timken bearings show lowest cost per ton of steel rolled.

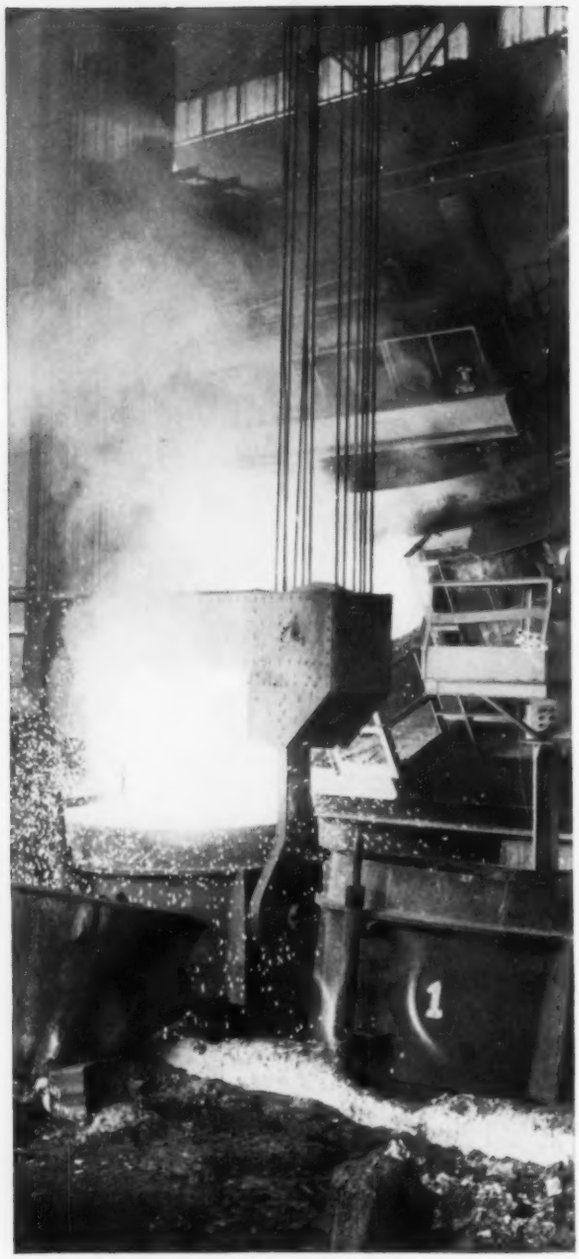
Always specify Timken balanced proportion roll neck bearings. For full details, consult our roll neck specialists. Write to: The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD



WHEN YOU MELT...

Lectromelt

Northeastern Steel also melts with Lectromelt®

Two new MT Lectromelt Furnaces give Northeastern Steel Corporation of Bridgeport, Connecticut, an average daily capacity of 350 tons of alloy, tool and specialty steels.

Ideally located for serving the needs of New England, Northeastern Steel offers a complete range of carbon and stainless steels—*certified* high-grade alloys for exacting uses like antifriction bearings, aircraft and machine tool applications. These two Lectromelt Furnaces provide the flexibility and dependability which assure uniformly high-quality steels.

Lectromelt Furnaces are described in Catalog No. 9-A. For a copy, write Lectromelt Furnace Company, 310 32nd Street, Pittsburgh 30, Pa. *(a McGraw Edison Company Division).*

. . . . to obtain a successful annealing line operation, close cooperation is needed between the mechanical, electrical and furnace equipment manufacturers. . . . speeds of such lines will undoubtedly increase, and one of the big problems to be solved is the development of improved methods of cooling rather than heating the steel . . . . advantages of the process are uniformity, flatness, greater stiffness, and absence of stickers . . . .

SYMPOSIUM on Continuous Annealing of Steel Strip

"GENERAL CONSIDERATIONS"

By HORACE DREVER
President
Drever Co.
Bethayres, Pa.

▲ THIS paper is confined to continuous annealing of tin plate strip. The paper following includes other types of strip.

The process of annealing tin plate strip by the continuous furnace, while not new, is not yet in common use although a very active interest is being given to it by those mills not equipped, the majority of the total number. There are at present six plants producing by this method, all however, as part of the total annealing plant. There are three mills with annealing lines under construction in Canada and the United States and the first high capacity line abroad is being completed in Wales. It is reported that a small horizontal line is in production in Germany and another, still smaller, is producing in Mexico. Active plans are on foot for other installations, either by those who have no continuous annealing lines or as added capacity by tin plate producers who already are producing by this method.

The earliest furnace on a production scale was an electric vertical furnace installed at Baltimore in Crown Cork and Seal Company in 1936. This was a 2-strip furnace with each strip rated 75 fpm, and while this furnace was not economical because of the slow speed, it did demonstrate the feasibility of the method and led immediately to the construction of a second and a third line, the last with a nominal rating of 300 fpm and a top speed of approximately 380 fpm. The product from these furnaces was stiffer and harder than batch annealed plate, and was looked on with scepticism by the steel industry in general, but it suffices to say that exactly the same qualities of plate are now yielded by the continuous lines that have been installed recently, qualities that are more and more being demanded by customers of the tin plate producers.

A few years after the Baltimore installation, the first gas-fired radiant tube furnace was built in the Ohio district as a pilot plant, but the metallurgists rejected the product as being harder and stiffer than batch annealed material and the line was dismantled. It did, however, demonstrate the practicability of gas firing in radiant tubes as the method of heating.

During World War II, the first line in Canada was put into operation by Dominion Foundries & Steel Co. This is still producing. This line is rated 300 fpm speed. The furnace is electrically heated with a rating of 1800 kw. A cleaner has since been installed ahead of the furnace, thus combining two operations. The product is used in quantities by the canmakers and many other types of fabricators.

That concludes the brief early history of the process. The question naturally arises why this method is so rapidly coming into favor for annealing tin plate strip, particularly when the heavy investment for even a modest size line is considered. The major answer probably can be summed up in one word—uniformity; uniformity of physicals, uniformity of surface. With the rapid increase in speeds, accompanied by automaticity of operation of forming equipment, uniformity of stock fed to the machine is the sine qua non. By its very nature, continuous strand annealing represents the ultimate in uniformity—batch annealing can never possibly approach it.

Other characteristics of strip annealed continuously are flatness, greater stiffness and the absence of stickers. All tin strip makers are acquainted with stickers which are encountered in the batch anneal and the trouble from them at the temper pass mill. This subject has

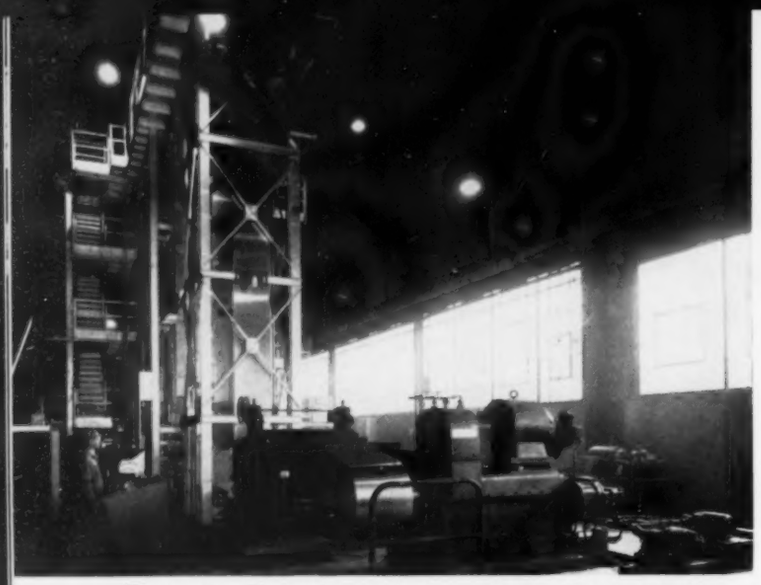


Figure 1 — Emerging strip has a flat uniform appearance upon exit from annealing line.

been discussed by Swisshelm (1).* It is generally agreed that the material from the continuous furnace is more easily rolled in the temper-pass mill than batch annealed coils. The product is uniform, does not have sticky edges and therefore should respond favorably. At one plant it is claimed that up to 25 per cent more production is realized when processing strip from the continuous furnace because of the freedom from stickers, but this is probably higher than the average.

Flatness of strip is effected by maintaining a controlled, uniform back tension when the strip is at its most elevated temperature and therefore in the most plastic state. The emerging strip shown in Figure 1 is a good illustration of this property. Contrast the flat uniform appearance of this with the irregularity of the strip entering the furnace in Figure 2. It is the common observation that strip of poor, irregular shape will be corrected in its treatment in a well designed continuous furnace provided the mechanical and electrical characteristics of the associated equipment are well set up. A rather unusual case to illustrate this ability to provide flatness occurs in a recent installation. One of the requirements of this mill is 0.018-in. stock for a continuous galvanizing line which does not include annealing in the line. By continuous annealing, the stock is delivered from the furnace flat enough to eliminate the necessity for temper-rolling, and goes directly from furnace to galvanizing department, thus saving one complete operation in a plant where temper passing is the bottleneck.

The trend in requirements of the consumers of tin plate is toward thinner gages and greater stiffness—the former made possible by the latter. Thicknesses less than the formerly standard 0.010 in. are common and Rockwell hardnesses have risen. The presently popular universal temper TU is replacing or consolidating the older tempers 4, 5 and 6. Typical of the specification for TU is the hardness of Rockwell 62–65 after temper passing which implies an aimed-for hardness of Rockwell 60–61 from the annealer, easily obtained in the continuous furnace but difficult in the batch furnace. A still harder requirement is for a

* Numbers in parentheses refer to Bibliography at end of paper.

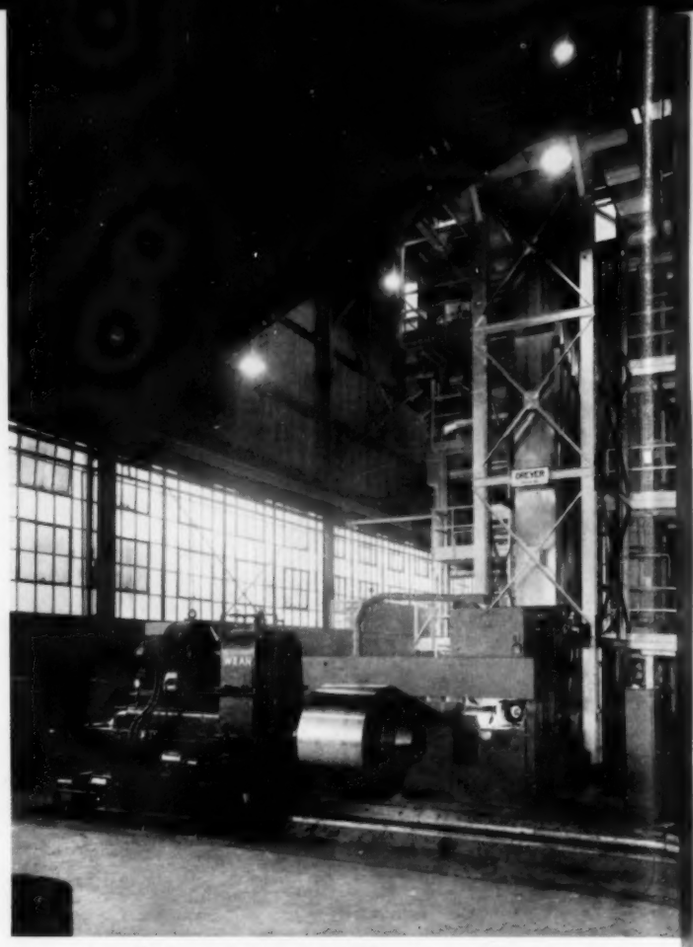


Figure 2 — Strip entering annealing line with irregularities, such as that shown, find these greatly minimized upon exit from the line.

plate, 0.0084 in. gage, with a minimum hardness of R 62 and a preferred range of R 65–70, obtained without rephosphorizing the steel.

Another advantage of continuous annealing over batch annealing is the complete elimination of sand spots. This occurs in batch annealing from entrainment of sand particles in the gas circulation used in the modern high power recirculating base fans. An outstanding characteristic of continuous annealed tin plate so far as the can companies are concerned, is the much superior corrosion resistance factor that can be obtained as compared with batch annealed plate. Pickle lag values are also materially improved over those obtained from batch annealed plate. (1)

A decided saving in processing can be realized if cleaning is combined with annealing, the already accepted procedure. This completely eliminates one entire operation and the heavy investment required for a separate cleaning line, including feeding uncoilers, welder, bridles and terminal bridles and recoilers. Both alkaline and electrolytic cleaners are used, the selection depending on the nature of the rolling lubricant. In a few cases of slow speed lines, flame cleaning has been used.

The ultimate capacity of the continuous annealing line has not yet been reached, and no one can predict with certainty what this will be, but compared with the speed of the tandem cold mill, the present operating and projected lines are slow. The fastest now operating is rated 1000 fpm on 30 x 0.010-in. strip and has run at speeds slightly in excess of this. A plant under con-

struction is planned to run at 2000 fpm for a nominal output of 60 tons per hour of 30 x 0.010-in. material, and present thinking seems to agree on this rating as the objective for the larger mills, at least until advances in heating, cooling and tracking techniques warrant an attack on higher speeds. The advantages of higher speed are apparent. Given a coil of a certain weight and dimensions, the mechanical equipment to handle this, and the associated electricals, vary but little with speed and therefore the higher the speed, the lower the investment per ton of output becomes. Labor per line remains almost constant regardless of speed, and therefore the cost per ton falls almost in straight line proportion to the increase in speed. Heat consumption is practically a constant per ton for any rated output. These factors are powerful incentives to attain the maximum speeds.

The furnaces used for the process are of two types, horizontal and vertical. The horizontal furnace has not been used for high production of tin plate although it is reported that a 3-pass furnace of this kind, with heat recuperative characteristics, has been used in Germany for a rated output of 7 metric tons per hour. In this country, all furnaces in recent years have been of the vertical type, either for strictly radiant type heating, by gas or electricity, or else a combination of high-gradient heating followed by the usual radiant furnace. A variation of this is the combination of high-gradient preheating to 600 to 800 F, finishing to maximum temperature in a radiant-heated furnace. The outstanding advantage of the vertical furnace is in economy of floor space, and this type has become accepted as the standard form. A very good description of a vertical furnace line is furnished in the paper by Weir (2). The heating and cooling cycle carried out in continuous annealing may be divided into four parts:

1. Heating to maximum temperature, 1200 to 1350 F.
2. Soaking at maximum finishing temperature.
3. Retarded cooling to 900 F.
4. Final cooling to just above room temperature.

There is little or no agreement among metallurgist or furnace designers of what constitutes the optimum cycle and it is apparent that a wide variation of each step in the series above is permissible, as demonstrated by the data in Table I.

TABLE I

Continuous Strip Annealing Furnaces
Heat Cycle for 0.010 x 30-in. Strip, Time, Sec

Customer	A	B	C	D	E	F	G	H
Heat	17	17	17	20	18	17	18	17
Soak	12	17	8	19	9	13	9	13
Slow cool	23	17	12	19	27	15	27	15
Fast cool	46	37	65	31	65	42	65	60
Final operation	..	..	..	Quench	Quench	Quench	Quench	..

With radiant heating, the first step, i.e., heating to final temperature, can be made in 15 to 20 sec for 0.010 in. material, with a maximum furnace (control) temperature of 1800 F. This condition permits stoppage of the strip and restart without danger of strip breakage. Higher temperature than this will cause a tear-off on restart and consequently a loss in production because of the necessity of re-threading. If high-gradient heating is used, upon slowdown or stoppage, the heating means must be instantly removed or else the strip will burn off and a re-threading operation will be necessitated. With high gradient heating, material 0.010 in. thick can be heated to annealing temperature in 2 to 4 seconds.

The second part of the cycle, soaking, is used only as a factor to insure that the strip is heated right to the center and can be allotted 8 to 15 seconds.

Retarded cooling is considered desirable by most metallurgists. Just what time should be allowed this phase for 0.010-in. material remains to be determined. In six cases examined by the writer, the ratio of slowest to fastest was $\frac{2}{3}$ to 1, and the properties of the annealed strip in all cases were acceptable by the ultimate user. The usual range for 0.010-in. material is from 15 seconds to 27 seconds. The principal variable so far detected is in the aging properties which can be compensated for in temper-passing.

The final step, cooling to final temperature, presents as difficult a problem as heating to annealing temperature. All surfaces of the strip must be exposed to a sufficient area of water-cooled surface for a sufficient time to transfer its heat by radiation, and as the strip is bright, its radiation factor is a minimum, and hence cools slowly. The recent trend in design of this part of the equipment is to cool down in enclosed chambers to approximately 400 F and then quench in water, followed by hot air blast drying. The metallurgical properties of the steel are not affected by this quenching but considerable time and equipment is saved. Any improvement in the cooling rates above permissible quenching temperatures appears to lie in the direction of combined radiation and convection heat transfer means.

To illustrate the variability of these steps in the heating cycle for various successful lines, attention is directed to Table I. It will be noted that the part of the cycle involving heating to top temperature varies but little; that time at soak has a range of more than 2 to 1; and the slow cooling period shows equally as much variation. There is no agreement whatever on the time required for final cooling, even though several furnaces are equipped with a quench to accelerate this part of the cycle. The only conclusion that can be drawn is as stated above: a wide variability can exist in this process for annealing low carbon strip.

Thus it appears paradoxically that the furnace builder must turn his ingenuity towards improved methods of cooling rather than heating the steel. Even with the mechanical and electrical means now available, which permit strip speeds in other processing lines of several times the fastest envisioned speed of 2000 fpm for any annealing line, it is certainly shortsighted to foresee extension by multiplicity of present cooling passes to permit such speeds. A marked departure from present thinking and conventional designs of cooling means, is the only answer to extension of annealing line speeds much over that being achieved today.

A cycle that has withstood the acid test of time is shown in Figure 3. This was constructed from thermo-

couple readings with the actual strip temperature at various points being measured. A second and much larger furnace line, based on this cycle, is now being constructed in the same plant.

The physical characteristics of the product of the continuous annealing furnace have not been discussed in detail for the reason that these have been discussed authoritatively by Weir and Swisshelm in this country and by Dr. Erich Schauff abroad. A reference to these papers is found in the Bibliography.

An interesting study has recently been made on steels from Europe. With the exception of slightly higher phosphorous contents (0.023) for basic open hearth compared to our normal open hearth practice, and lower phosphorous (0.035) in the basic bessemer as compared to acid bessemer, the ladle analyses were comparable to our open hearth steel. Samples of the strip revealed exceptionally low carbon (0.027 to 0.038) and slightly low manganese contents as compared to a typical type MR open hearth steel. The open hearth steel also revealed slightly high phosphorous and copper contents.

The properties of the annealed strip were generally satisfactory. However, a wider variation in hardness values was noted in TU cycle annealing, and more speed adjustments were required during annealing the bessemer stock than were required while processing the open hearth material.

The following results of tests made after temper rolling and before and after tinning were reported from France:

1. The uniformity of Rockwells obtained between edge and center, and top or bottom of ingot were exceptionally good compared to batch annealed strip.

2. Final Rockwells obtained on tinplate for Temper 4 were identical with those obtained for batch annealed stock. The Thomas steel gave TU Rockwells of 62 to 66 very easily, and the results of temper rolling were good for the Thomas steel.

3. Elongations were greater for the continuous annealed tinplate than batch annealed, this being due to a microscopic structure which was more regular and less sensitive in the presence of lines of segregation.

4. Rockwells obtained after tinning are more stable and artificial aging tests do not produce the changes normally expected from batch annealed tin plate.

5. Micrographs show a much better formed grain in the mid-thickness after continuous annealing than after batch annealing, and the presence of non-recrystallized zones which frequently occur in batch annealed plate, have not been found in the continuous annealed plate. This is believed due to the fact that segregation lines, if present, in continuous annealed plate, do not impede recrystallization.

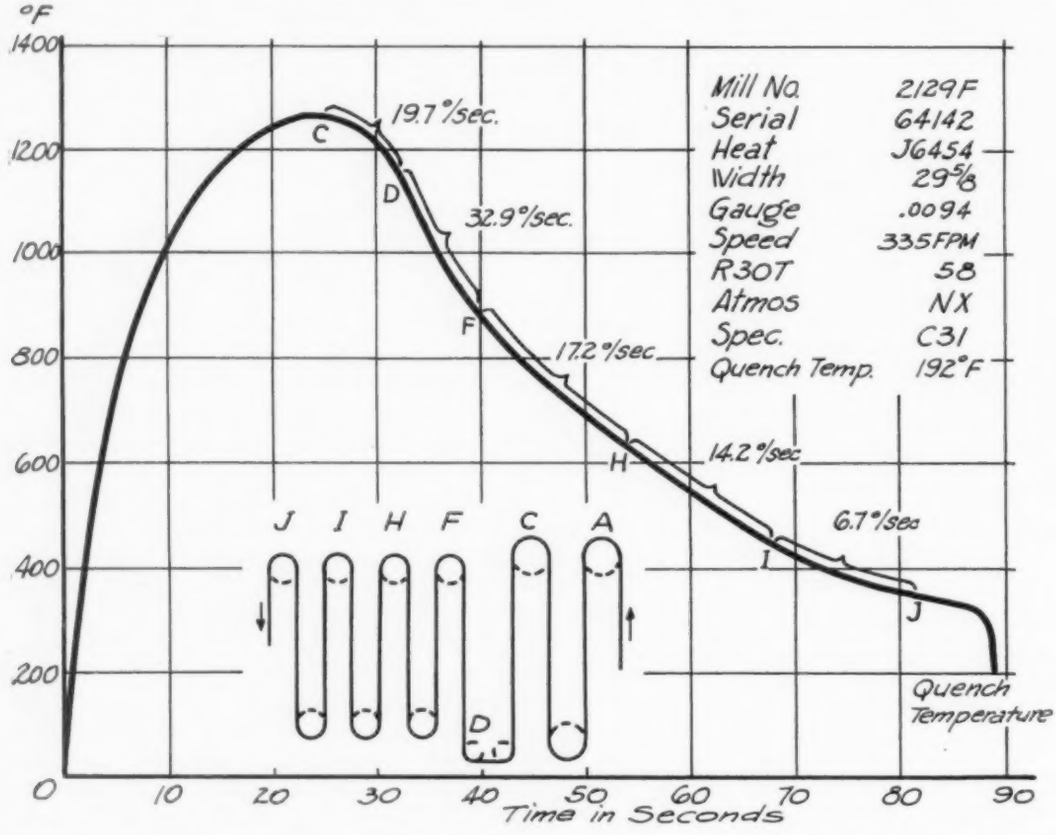


Figure 3 — Chart gives typical vertical annealing furnace temperature cycle.

The manufacture of low carbon steels by the oxygen-blown converter is too recent to provide authentic data on the characteristics of the continuously annealed product. Preliminary work indicates unusual properties and it is hoped that in another year we will be able to report on this steel.

In conclusion, we believe that the continuous process deserves the unbiased study of the steel producer, whenever new annealing capacity is being considered.

Bibliography

1. "Quality Comparison of Box vs. Strip Annealing of Tin Mill Products," by W. H. Swisshelm, 1955 Proceedings AISE.
2. "Continuous Annealing of Strip Steel at Dominion Foundries & Steel Co.," by W. R. Weir, 1950.
3. "Criticism and Comparison of Heat-Treating Facilities in Cold Rolling Mills," by Dr. Ing. Erich Schauff, Iron & Coal Trades Review, December 10, 1954.

DISCUSSION

PRESENTED BY

J. I. GREENBERGER, Group Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

J. J. REMLEY, Steel Mill Engineering, Systems Application Engineering Section. General Electric Co., Schenectady, N. Y.

HORACE DREVER, President, Drever Co., Bethayres, Pa.

J. I. Greenberger: This fine paper clearly reviews past experiences on continuous annealing lines and projects these experiences into evaluation of probable future trends. My company's experience in the field of high speed continuous annealing obtained in the engineering, building and operation of the four highest speed operating lines would lead us to temper Mr. Drever's high speed thinking somewhat. The mechanical considerations of handling strip in such high speed lines, particularly ahead of the furnace where the strip is in a full hard cold rolled condition, are vitally important. Such considerations as the use of looping type storage towers as opposed to free hanging loops must enter the high speed picture. Cold rolled strip shape itself is another limiting factor. We anticipate higher successful operating speeds than our present 1000-fpm lines which were a threefold increase over previous line speeds, but speeds above 2000 fpm seem far in the future.

We wish to confirm Mr. Drever's thinking that one of the real problems in the high speed continuous annealing line is that of strip cooling to terminate the cycle. An important additional means of cooling which was suggested by us for use in these higher speed lines and which is now in successful operation, is the use of controlled cooling rolls. Strip thicknesses and thermal conductivity factors are of such magnitudes that rapid cooling is obtained by the use of such rolls.

One question which Mr. Drever would perhaps care to answer is how much or what modification to present continuous annealing line furnace design would be necessary to permit changing of cycle time distribution in a given installation. In other words, why not have a flexible furnace installation which could easily change the time ratios of the heating, holding, slow cooling and fast cooling zones.

Mr. Drever did not mention furnace atmospheres and we were wondering if he would wish to comment on which of the various furnace atmospheres is most nearly correct in his opinion, and why.

J. J. Remley: It has been our experience that the flatness of strip, uniformity, and consistent high Rockwell hardness makes the continuous process desirable for tinplate as pointed out in this paper. Our company furnished equipment for two annealing lines installed at the Midland plant of the Crucible Steel Company in 1936. These lines were taken out of service in 1940. The first 1000-fpm tinplate annealing line was installed at Gary Sheet & Tin Mill in 1951 followed by the 1000-fpm line at Fairless Works in 1952. These lines are rated at 30 tons per hour of 0.010-in. strip. The mechanical drive equipment was furnished by Mr. Greenberger's company. The furnace is combination gas and electric with a gas fired heating section and an electrically heated holding and slow cool section. We supplied the furnace and the electrical drive equipment, subcontracting the gas fired heating chamber.

The dramatic changes in continuous annealing which have occurred in the past have been possible because of close cooperation between the mechanical equipment builder, the furnace manufacturer, and the electrical supplier. Continuous annealing lines are now being built for 2000 fpm. These lines bring up new problems in tracking and tension control in the furnace in addition to the problem of heating and cooling the strip. Continuation of this cooperation will make further advances in the art possible as more experience is obtained.

Horace Drever: Mr. Greenberger has raised three questions in his discussion of the above paper. The first of these was on the use of cooling rolls to produce more rapid cooling of the strip. The chief difficulty in attempting to cool the strip by means of cooling rolls is that strip distortion becomes too great due to the unequal cooling of the roll face combined with the fact that there is uneven strip pressure contact on the roll surface. These two factors combine to produce distorted strip and greatly magnify strip tracking problems through a continuous annealing line.

Mr. Greenberger's second question is: "How much or what modification to present continuous annealing line furnace design would be necessary to permit changing of cycle time distribution in a given installation?" I would paradoxically answer with the question: "Why is there any necessity for providing any greater cycle flexibility than that which may be obtained inherently in the present design of continuous annealing furnaces?" Our reason for asking this question is based on rather sound experiences with continuous annealing operations over the past five to ten years. There are four types of product which have proven to respond economically to processing in a continuous annealing line. These materials are: (a) tinplate, (b) galvanizing stock, (c) silicon steels, and last and not too usual, processing of enameling stock. Of these four types of cycles it is quite possible to produce three of them on any of the continuous annealing lines at present in operation. These are tin plate, galvanizing material and enameling stock. All three of these have been successfully produced on one continuous annealing furnace line. Hence there is no need to provide cycle flexibility other than that inherent in the design of the furnaces, in order to produce these three types of product. The fourth type, which is a silicon steel, by reason of its peculiar nature, of necessity has to be produced on a line which is designed to meet the particular requirements for three types of annealing cycles. This is quite practical and has already been done successfully on the Vandergrift lines which have been designed and have been using the three different cycles required for silicon process. However, because of the higher temperatures encountered, the problem of pick-up on the rolls which is also present in normalizing lines makes it necessary to provide a very expensive type of roll surface in order to successfully anneal silicon steel in a continuous annealing furnace. Tin plate could be quite successfully annealed in a continuous annealing

furnace designed for silicon steel, however, due to mechanical wear on a very expensive type of roll, which is not required in the case of tin plate annealing, it is not too economical to design a furnace for silicon steel and produce tin plate with it.

The main practical variation in cycle required on any given line is a speed variation to take into account variation in gages and types of material being processed. However, this variation is found to be restricted over a very narrow range for the type of materials being processed. The main factor which must be considered is that continuous annealing, in order to be economically comparable to other forms of annealing, despite its added advantages of greater uniformity of product and several other intangible advantages realized in subsequent processing, must be of a high production nature in order to fully realize its economic advantages. Because of this fact, the continuous annealing line is never considered to be a jobbing shop type of line whereon great flexibility of annealing cycle is a direct requirement. It has therefore proven quite practical to design a continuous annealing line to produce over a fairly narrow range of production, and its acceptance to the industry has only been due to the economics presented by the larger production capacity lines. We therefore believe that greater flexibility of annealing cycle is not a real requirement in continuous annealing furnaces.

The last question which Mr. Greenberger raises is that of the correct furnace atomosphere for continuous annealing. Here again the product being annealed is the determining factor. In the case of silicon steels, the processing is too involved to discuss the variations in atmosphere gas requirements within the scope of this paper. In the case of tin plate, the question of which is the best atmosphere is a highly controversial one even to this day. Wheeling Steels' continuous line at Yorkville and the No. 1 Dominion Foundries & Steel Co.'s annealing line have been producing for years on exothermic gas. As opposed to this, the U. S. Steel lines at Gary and Fairless, The Steel Company of Canada line in Hamilton, and the No. 2 Dominion Foundries & Steel Co. line recently completed have been operated on CO_2 and CO free atmospheres containing largely nitrogen and four to eight per cent hydrogen. The operators of these lines have expressed an opinion that CO_2 and CO removal were necessary to obtain the best pickle lag test results on tin plate. Whether the cost of producing the CO_2 and CO free atmosphere can be justified by improved pickle lag results has not been determined by the author. The selection of the proper atmosphere gas at present seems to rest with the judgment of the purchaser of the equipment based on his knowledge of his own customer's product requirements.

We are in complete accord with Mr. Remley's remarks and would desire to stress the fact that in order to obtain successful operation of a continuous annealing line, close cooperation is required between the mechanical equipment builder, the furnace manufacturer and the electrical supplier, which has not been required on other types of cold processing lines. We believe that all equipment builders who have been involved in the design and construction of a continuous annealing line in the past will be heartily in accord with this view.

"FURNACES"

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▲ FURNACES for the continuous annealing of steel strip on a large tonnage basis have been limited to three principal fields of application up to this time.

One field is the annealing of tin plate. Considerable development over many years has shown that the most suitable type of continuous furnace for this application is the vertical multiple strand furnace. Tin plate thicknesses ranging from 0.007 to 0.015 in. were of suitable size to allow passage over reasonable size rolls at both elevated and lower temperatures encountered during cooling.

Another field where strip thickness is within a range suitable for the vertical type furnace is silicon steel strip 0.01 to 0.035 in. thick.

In the field of annealing for galvanizing, the vertical furnace is suitable for thinner gages up to 0.04 in. thick. For heavier gages, the horizontal roller hearth type either straight through or multiple strand type is used. In the case of the multiple strand horizontal furnace, the pass rolls are larger diameter than those used in vertical furnaces, speeds are slower and heavier gages up to 0.125 in. thickness are processed because the strip does not change direction over pass rolls except at temperatures of 1100 F or over. In continuous galvanizing, the strip is not cooled below temperatures of 900 F so that bending of heavier gage strip around pass rolls at lower temperatures is not a problem.

This discussion will deal principally with the design considerations of a large size vertical strand annealing furnace applied particularly to the annealing of tinplate.

FURNACE CAPACITY RANGES

Tin plate lines in operation and under construction using the vertical furnace vary in strip speed from 300 to 2000 fpm. The corresponding variation in tonnage rates are from 10 to 60 tons per hr. Some studies made in the earlier development stages indicated that in order to justify the rather large capital expenditures for a complete continuous annealing line, the capacity should not be less than about 15 tons per hr. This minimum capacity is required also if overall operating costs are to be comparable with the average overall costs of batch annealing. These are general guides, but the conclusions clearly indicated that in order to keep the investment cost per ton down to a reasonable value, that higher line speeds are of prime importance since the cost of mechanial and electrical equipment for strip handling exclusive of the furnace

does not vary much with speed. Also labor costs per line do not vary greatly with speed.

Advances in developments of strip handling and minimizing of strip tension, coupled with improved heating and cooling methods have made it practical to justify a 2000-fpm line now under construction.

FURNACE CYCLES

The use of higher strip speeds requires close attention to the use of the minimum time cycle in order to reduce the number of passes as much as practical. A line speed of 2000 fpm requires 33.3 ft of strip for each second that it is in the furnace. It is therefore quite desirable to keep the cycles relatively short. From a metallurgical standpoint the strip may be heated very rapidly by any of several methods. The time required metallurgically to soak and to slow cool (a relative term) down to about 900 F is subject to considerable differences in metallurgical opinion. Below 900 F the steel may be cooled as rapidly as possible without any marked change in the metallurgical results.

Values of soaking time at temperature of existing and proposed installations range from 6 to 18 sec.

Values of slow cooling from 1350 to 950 F range from 10 to 22 sec.

These relatively wide ranges of soak and slow cool times do not seem to cause much change in metal-

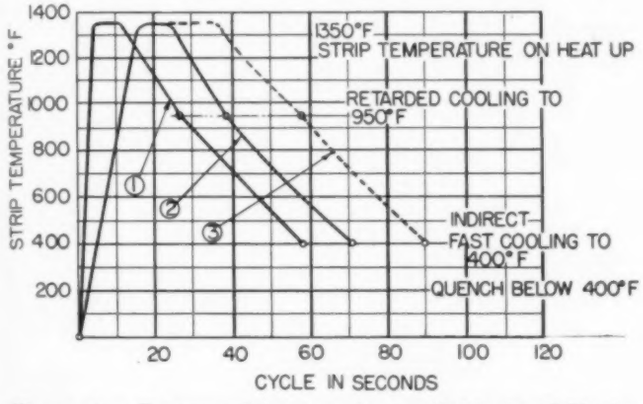


Figure 1 — Ranges of heat cycles available for 0.01 size strip are given on the three curves.

lurgical results. However, times below the minimums given above cause an appreciable increase in tendency to age harden.

The range of cycles of 0.01-in. thick strip possible without marked changes in required metallurgical results is shown by the curves in Figure 1. These curves also indicate other information of importance. Curve No. 1 and curve No. 2 indicate about the minimum time cycle if age hardening is to be avoided. Curve No. 1 illustrates a heat up time of 4 seconds compared to a heat up time of 20 seconds for curve No. 2. The faster heat up time corresponds to direct firing at high temperature gradients of 2200 F in furnace temperature in order to impart heat to the strip at a high rate. Curves No. 2 and No. 3 each show a heat up time of 20 seconds which corresponds to using gas-fired, radiant tubes maintaining a furnace chamber of 1600 to 1650 F while heating the strip to 1350 F.

Curve No. 3 indicates longer soak and slow cool times. All curves have the same cooling time from 950 to 400 F. Strip is quenched into water at 400 F.

TABLE I

Curve	Total cycle, sec	Lineal Feet Required in a Furnace		
		At 500 fpm	At 1000 fpm	At 2000 fpm
1	52	434	868	1736
2	68	568	1136	2272
3	92	765	1530	3060

The lineal feet of strip required to be in the furnace for the cycles given in curves of Figure 1 are shown in Table I. After determination of the vertical length of the pass the number of passes required can be determined from the table for the various cycles.

METHODS OF HEATING THE STRIP

During the earlier stages of the development of continuous annealing, the writer made an appraisal of the overall advantages, disadvantages and economics of heating strip steel continuously. The details of this study are in an article separately published (1)* The general results of the study are still applicable to the present status of developments in this field, and will be summarized in order to establish the reasons for choosing the specific heating method applying to the furnace described in this present discussion.

The basic requirements for a good overall heating method are:

1. Rapid heating in order to limit amount of strip length required in the furnace.
2. Good fuel economy.
3. Good control of prepared atmosphere to maintain brightness of strip.

Out of the various methods studied, four were considered to be applicable to meet these requirements. The results are tabulated in Table II. The heating time of 0.01-in. thick steel strip with bright finish at various gradients is shown on Figure 2.

The general conclusions drawn from this study were as follows:

1. High speed electric heating methods by high fre-

* Numbers in parentheses refer to Bibliography at end of this article.

TABLE II

Comparison Methods Heating 0.01-in. Thick Steel Strip to 1350 F

Method	Heat up time, sec	Btu per ton	Kwhr per ton	Energy cost per ton
High frequency induction	1.0	...	258	$2.58
Electric resistors furnace 1700 F	14	...	130	$1.30
Direct gas-fired furnace—2300 F with 300 F preheat	3.5	1,376,000	..	$0.55
Radiant tube gas-fired furnace—1700 F	16	1,116,000	..	$0.45
Radiant tube gas-fired furnace—1700 F with recuperator	16	770,000	..	$0.31

Note—Figures are based on electric energy at 1.0 cent per kwhr and fuel gas at 40 cents per million Btu.

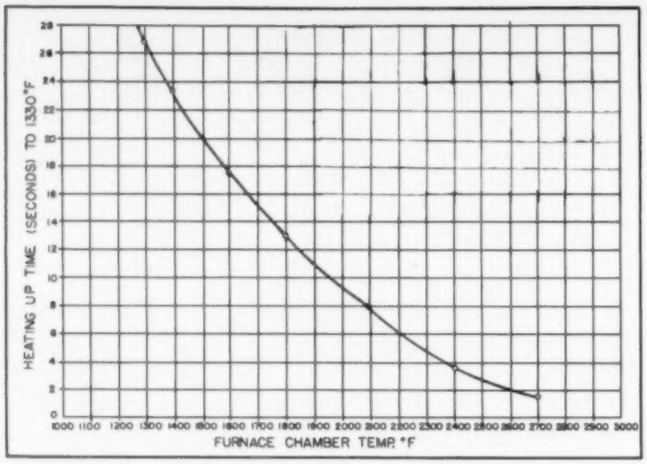


Figure 2 — Times of heating 0.01-in. thick strip to 1330 F with various furnace chamber temperatures. The heating times for other thicknesses are in proportion to the times given in this chart.

quency induction applied to the annealing of steel strip are too expensive for large tonnage installations due to high first cost and high operating cost. Although the initial heat up section can be very short, the overall saving in strip length in the furnace is small since most of the length is required for soak, slow cool and further cooling of strip down to suitable quenching or exit temperatures.

2. Use of electric resistor heating is the preferred method when the costs of electrical energy are not out of line with gas fuel costs.

3. Gas fired radiant tube heating on a gradient is a desirable method for high speed high tonnage lines when cheap gaseous fuel is available.

4. Direct gas firing on a gradient is also a fast economical method, but times of exposure during heat up without a protective atmosphere must be kept to a few seconds to prevent oxidation. This requirement also places a limitation on number of heating passes and tends to limit line speeds to between 500 and 1000 fpm.

The particular furnace described in detail in the present paper is heated by means of gas-fired radiant tubes for a strip speed of 2000 fpm. The chamber temperature is maintained at 1600 to 1650 F while heating the strip to approximately 1350 F. The soak and slow cool sections are equipped with electric heat in the form of resistors. Electric heat is ideal for these sections since the heat is spaced over large areas and can be properly placed and closely controlled. It is also economical in these portions (even though unit energy cost is considerably higher than gaseous fuel) because the electrical energy in these sections is used principally to supply losses, which are a small percentage of the total energy requirements for heating the strip.

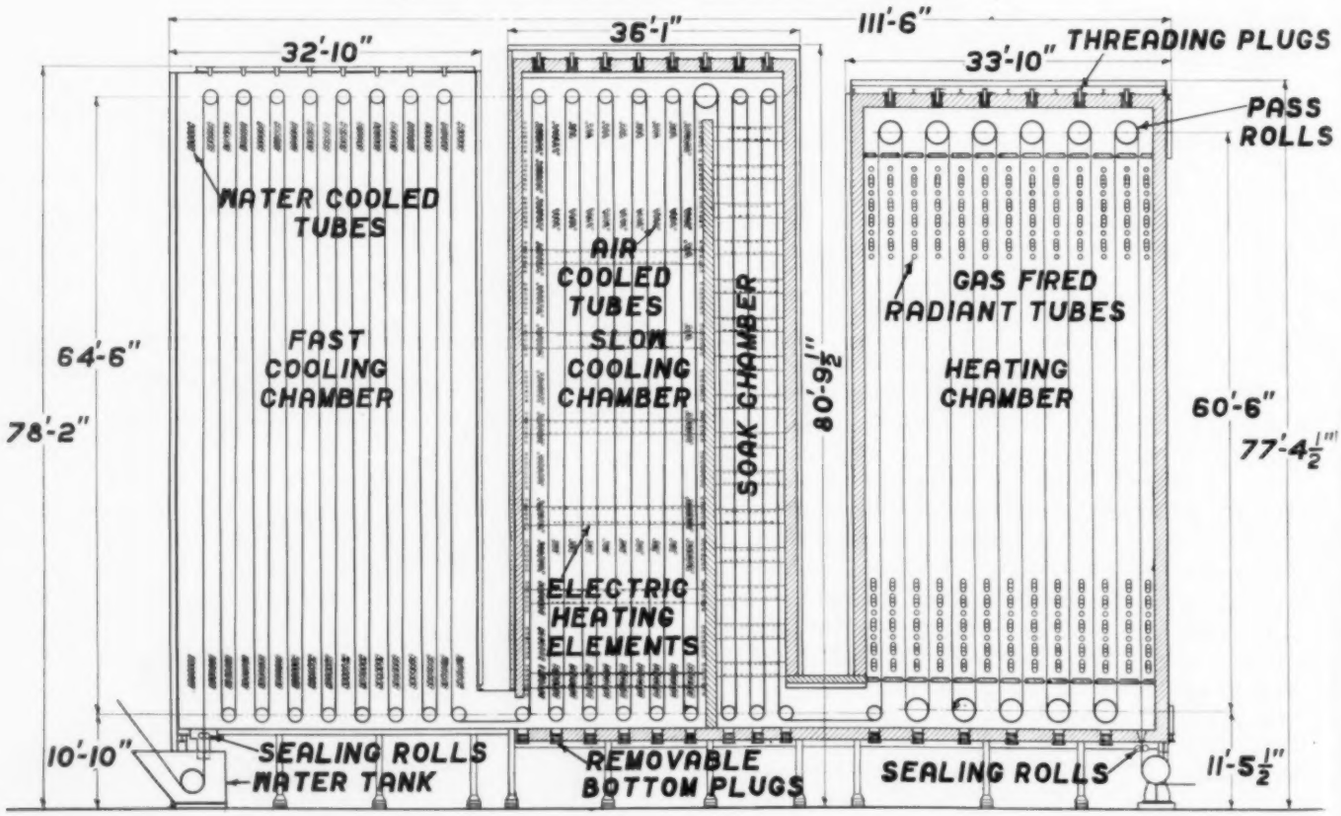
DESCRIPTION OF FURNACE

As an example of continuous annealing of tinplate, a furnace will be described rated at a nominal value of 60 tons per hr based on strip 0.01 in. thick and 30 in. wide traveling at 2000 fpm.

The furnace is designed to heat the strip at these rates from room temperature to 1350 F in the presence of a protective atmosphere with the average furnace chamber temperature at 1650 F. The heating chamber of the furnace can be operated up to a maximum temperature of 1800 F.

The furnace structure consists of four principal components:

Figure 3 — Longitudinal schematic section of furnace.



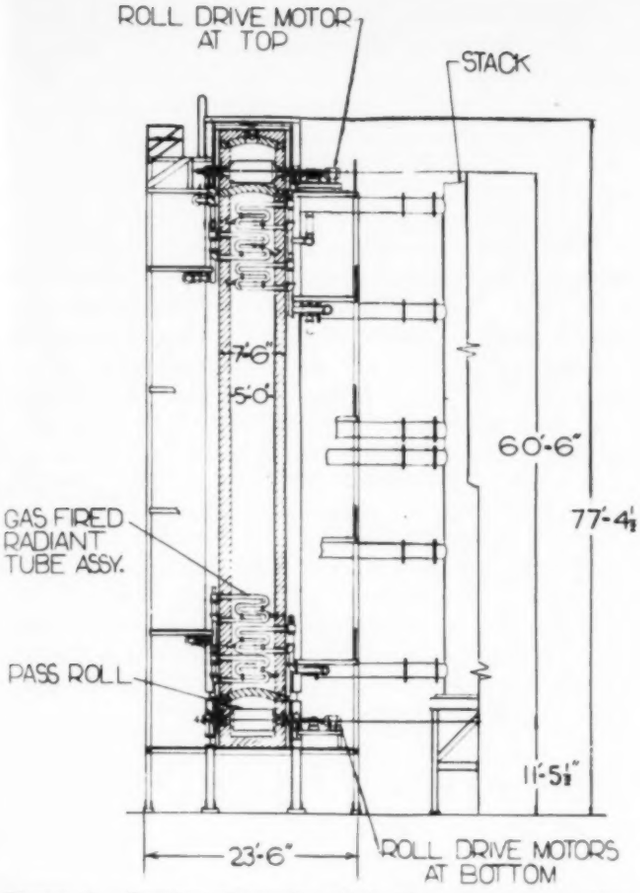


Figure 4 — Section through width of furnace at heating section.

1. Gas fired radiant tube heat-up section.
2. Electrically heated soak section.
3. Slow cool section with air cooling tubes and electric heat.
4. Water-cooled section.

A longitudinal schematic section of the furnace is shown in Figure 3. A section through the width of the furnace of the heating section is shown in Figure 4.

The furnace can handle strip up to 45 in. wide gage, thicknesses of strip may vary from 0.0075 to 0.025 in.

THE GAS FIRED HEAT-UP SECTION

This section consists of 12 passes heated by means of "W" shaped radiant tubes radiating directly to both sides of the strip on each pass line. At 2000 fpm the time required for the strip to go through the heat-up section is approximately 23.2 sec. The strip is exposed to radiation from the tubes for 19.5 sec. In order to heat the strip to 1350 F, the average heating chamber temperature is approximately 1575 to 1600 F. The heat-up section is divided into six temperature control zones. The maximum heating capacity of the heat-up section is 80,000,000 Btu per hr. This allows a potential production capacity of 75 to 80 tons per hr on wider strip and on cycles where strip is heated to values less than the maximum of 1350 F ergo 1250 F. About 775 ft of strip is required to fill the heating section.

The heating section is lined with refractory walls approximately 15 in. thick with an inner course of 9 in. of 2600 F insulating refractory. The remainder, consisting of block insulation brick walls, are anchored to the steel shell and all outer walls are supported at intervals by separating ledges built into the steel shell.

THE BURNERS AND COMBUSTION CONTROL SYSTEM

The radiant tubes are gas-fired, using a specially developed integral burner head and exhaust duct arrangement, to preheat the combustion air to approximately 800 F or over. This gives very efficient combustion and good overall fuel economy. The burner system is designed especially to burn coke oven gas containing high sulphur content (300 to 400 gr per cu ft). It will also burn natural gas or mixed gases.

Each burner head is a self-contained adjustable combustion unit, complete with individual constant burning pilot, which is maintained very stable by having the pilot air gas mixture fed from a separate system to the pilot under strong positive pressure of a minimum of 6 to 8 in. of water. Each burner has its own adjustment for proper air-gas ratio, and long flame characteristics necessary for efficient combustion in a radiant tube.

The complete radiant tube and exhaust system is under a suction pressure imposed by a master blower which handles the hot exhaust gases, after partial dilution with cold air on the discharge side of the radiant tube. At each burner, the combustion air is drawn into the recuperator housing on the burner and is preheated by means of heat interchange with the exit exhaust gases from the radiant tube. An adjustable aperture in the burner head allows proper setting of the amount of preheated air to be admitted to the burner. The fuel gas is admitted separately under pressure into the center of the burner housing.

The exhaust duct header from each temperature control zone is equipped with either a motorized or air-operated valve system activated by the temperature control instrument for that zone. The inlet fuel gas line to each zone is also equipped with a suitable control valve actuated by the temperature control instrument of that zone. The control action for each gas-fired zone is on-off so that control valves are either open or closed depending on heat demand.

THE SOAK SECTION

This section consists of five vertical passes. It is heated by means of electric resistor elements mounted on the walls of this section. The principal function of the electric heat is to compensate for wall losses and maintain a uniform temperature in this section. Thus only a small amount of heat is actually required during normal operation, and the fact that this heat must be dispersed over a large area makes it desirable to use electric resistors which can be readily spread out over this area. This section is rated at 550 kw, divided into five vertical control zones. This rating is not used in normal operation, but is installed so that when furnace is started up from a cold condition, enough energy will be available to bring the soak section up to temperature in about six hours. Provision is made to switch this power from the delta connection used on start up, to a star connection for normal operation. This reduces the power to one third of its original value which is

still ample to supply all necessary radiation losses from the walls of this section. The control at reduced power is of the conventional on-off type. At 2000 fpm, the time required for the strip to go through the soak section is 10 sec and about 333 ft of strip are required to fill this section.

SLOW COOL SECTION

This section consists of 11 passes and cools the strip from 1350 F to about 900 F, pulling air through the inside of banks of cooling tubes located on each side of the pass line across the width of the furnace. Each bank of tubes is removable as a unit complete with mounting flange and insulating plug.

Electric resistor elements are mounted on the walls of this section in order to supply heat to bring the furnace up to temperature and equalize the heat in this section before any strip is put through. This heat is divided into four control zones, two zones rated 300 kw each, and two zones rated 200 kw each, capable of bringing furnace up to temperature from a cold start in about six hr.

The cooling tubes are also divided into four control zones. Cooling is controlled by means of butterfly proportioning valves located in the exhaust header from the banks of cooling tubes corresponding to each control zone. These valves are operated through proportioning type temperature controllers, which can be set to automatically hold the zone at the particular cooling temperature desired.

These same controllers, through an extra contact, can act to automatically call for electric heat in the same zone in those instances where cooling rates may be faster than desired. Under most operating conditions, however, electric heat will not be required, to retard the cooling. The cooling load will be controlled by the amount of air allowed to exhaust through the cooling tubes of a control zone as governed by the position of the butterfly proportioning valve used in the control for each zone.

The time required for the strip to pass through the slow cooling section at 2000-fpm speed is 22 sec. The amount of strip required to fill this section is about 733 ft.

FAST COOL SECTION

The term "fast cool" is only a relative term in that from a metallurgical viewpoint, the strip can be literally quenched after it has cooled down to 850 to 900 F. However, practical limitations do not allow quenching from this high a temperature.

The limitations consist of:

1. Possibility of small amount of discoloration.
2. Possibility of distortion of strip.

To avoid these problems, indirect cooling methods are used. In the design described here, the cooling section consists of 14 passes. The strip is cooled in the protective atmosphere from a temperature of around 900 F to a temperature of about 450 F, and then quenched directly into a water bath without exposure to air.

Cooling is accomplished by means of a series of unit banks of water-cooled tube assemblies mounted across the width of the furnace and facing the strip on each side of the pass line. Thus the cooling is done by low temperature radiation and natural convection. The cooling tubes have fins on the side exposed to the protective atmosphere in order to obtain more effective surface for convection cooling. Recirculation of atmosphere or forced convection is not used in this section. It is difficult to maintain uniform static pressure of the controlled atmosphere in the chamber when using methods of forced circulation. In order to prevent ingress of small amounts of oxygen, the furnace must be perfectly tight and large amounts of protective atmosphere must be used. Otherwise discoloration of the strip will take place. In addition, the speed-up of cooling by using forced circulation is not as marked when cooling the strip from 900 F to 450 F, as when cooling the strip in protective atmosphere all the way down to 250 F or less.

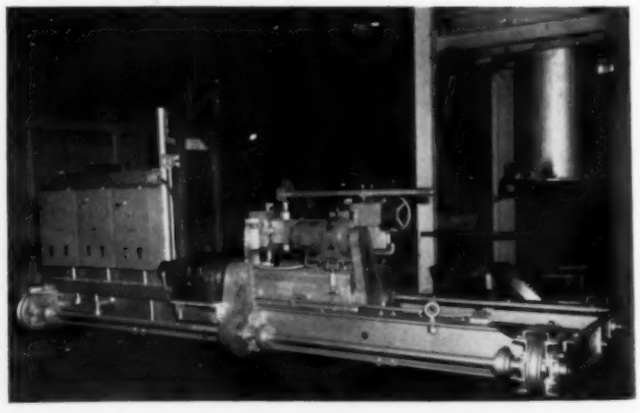
At a strip speed of 2000 fpm for 0.01 in. thick strip, the number of additional passes which would be required to cool the strip in protective atmosphere from 450 F to 250 F amounts to 24 passes. Thus there is a considerable reduction in cooling chamber passes realized by quenching into water at 450 F.

GENERAL FEATURES OF FURNACE CONSTRUCTION

Rolls and roll bearings—The main pass rolls are shaped so that contact surface with the strip is narrower than the strip when passing over the roll. This means that there is a small offset in the roll surface beyond the center area. These are termed "narrow bodied" rolls and when used in conjunction with self-centering rolls outside of the furnace, they are designed to keep the strip accurately centered on the pass rolls with minimum tensions at high strip speeds. This combination is designed to eliminate causes of strip breakage due to the strip wandering off the center of the rolls particularly at higher speeds. This combination is to be used in the 2000-fpm speeds proposed for the furnace described here. The complete discussion of this application is covered in a paper by E. T. Lorig. (2)

Roll bearings are self alining roller bearings, water-cooled and grease-lubricated from a central lubrication system. The bearings are mounted on a separate support structure so as to accurately maintain alinement independent of furnace expansion. Bearings on the off

Figure 5 — Bottom pass rolls are removed by means of a special car.



drive side are capped for tightness against loss of atmosphere. Bearings on the drive side are provided with mechanical seals for gas tightness. Expansion between the shell and supporting structure is taken up by means of metal bellows.

Each pass roll is individually driven through suitable gear reducers by d-c motors with adjustable voltage control. This allows operation over a range of speeds for various gages and also allows control of speed of each individual roll so that all rolls turn together properly for a given speed setting.

All rolls are removed sidewise in a direction parallel to the axis of the roll. In order to utilize space on the side of the furnace efficiently all rolls are removed from the same side of the furnace. Pass rolls at the top of the furnace are removed by means of a counterweighted fixture handled by the shop overhead crane. Pass rolls at the bottom are removed by means of special roll removal car and moved to one end of the furnace where they then can be handled by the shop crane if desired. The roll removal car is shown in Figure 5.

Counterweighted fixtures are also provided for removal of radiant tube assemblies and air-cooled and water-cooled tube assemblies. These fixtures are handled by an auxiliary crane on the side of the furnace where shop crane is not readily accessible.

Strip breakage-threading—In a multipass furnace of this type, it is important to be able to quickly locate where a strip break has occurred. The furnace is provided with an electrically-operated system to signal and indicate location in the furnace of a possible strip break. If a break occurs, the strip drops from the bottom pass roll to make contact with a heat resisting alloy electrode each located under a pass roll. As contact is made, necessary relays function to shut down the strip line, sound an alarm indicating that a break has occurred, and indicates the location of the break by means of a visual indicating annunciator station.

The general procedure for rethreading after a break is as follows:

After location of break has been determined, a 4-in. pipe plug is removed from the affected roll and the threading chain is dropped down on either side of the roll. At the bottom where the corresponding threading plugs have been removed, the threading chains are attached to adapter pieces and the latter is welded to the strip ends.

Plug removal underneath the furnace as well as replacement of such plugs is done by means of a manually-operated plug removal car with hydraulic jack to operate under the furnace on floor track.

Access to furnace for observation and maintenance—Each pass is provided with peep holes at top and bottom.

Each pass is provided with gas tight, removable plug assemblies at top and bottom for access to rolls, etc. Four-in. pipe openings are located in the top plug assemblies for localized and limited access for quick threading purposes.

Access openings into each principal chamber at each platform level are provided for inspection purposes or maintenance purposes when furnace is shut down.

Atmosphere control—The complete furnace structure must be designed for gas tightness since it is filled with protective atmosphere to maintain a bright finish on the strip as it passes through the furnace.

All tube mountings in heating and cooling chambers are made in unit assemblies and are flanged mounted and gasketed for tightness.

All parts of the structure are welded gas tight.

The principal sources of atmosphere loss are at the entrance and exit of the furnace. At these points, motor-driven sealing rolls are provided. These are sealed at all points except where the strip passes through between the rolls. In order to maintain a reasonable static pressure of 0.2 to 0.5 in. of water in such a large furnace structure, atmosphere consumption is estimated to be between 15,000 and 20,000 cfhr. The type of atmosphere used is processed combusted fuel gas in which CO_2, H_2O and CO are removed leaving a dry gas containing 5 to 10 per cent of hydrogen and the balance nitrogen.

The furnace is provided with instruments to record furnace pressure and flow of atmosphere to the principal sections. Also recorders are provided to indicate oxygen (normally should be zero) and the amount of hydrogen in the atmosphere.

Strip temperature measurement—Temperature recorders using radiation type pickup are used to measure and record the temperatures.

1. At the end of the heat-up zone.
2. At the end of the soak zone.
3. At the end of the slow cool zone.
4. At the end of the fast cool zone.

Average operating requirements—Based on heating strip to 1350 F, at rate of 60 tons per hr, of 30-in. wide by 0.010-in. thick strip, there will be required:

1. Coke oven gas (525 Btu)—1400 cu ft per ton.
2. Electricity, including motors for combustion and exhausting—9.0 kwhr per ton.
3. Water (based on 40 F rise)—800 gal per ton.

SUMMARY

The trends in development of heating steel strip indicate an expanding use of the continuous vertical strand annealing furnace. Quicker processing, and uniformity of product are plus factors over more conventional batch annealing. The furnace will be refined and improved as further experience is gained in various segments of the industry. Development trends point toward further reduction of the number of passes required in the overall furnace cycle. Further investigation or shorter cycles will simplify the furnace if shorter cycles can be realized and still meet the various metallurgical requirements of the user of the material. Further improvements in cooling can shorten the amount strip stored in the furnace. Simpler furnaces with fewer passes will allow a further step up in speeds through the furnace and thus reduce still more the initial investment cost per ton and operating cost per ton.

BIBLIOGRAPHY

1. "A Comparison of Economics and Methods for Heating Steel Strip," by C. E. Peck, Blast Furnace and Steel Plant (July 1954).
2. "Application and Use of Self Centering Rolls," by E. T. Lorig, 1954 Proceedings AISE.

DISCUSSION

PRESENTED BY

E. J. SEABOLD, Consulting Engineer, Westinghouse Electric Corp., Meadville, Pa.

E. J. Seabold: One phase of this subject appears to be still open; and that is the wide variation of time permissible in the optimum heat treating cycle.

It is doubtful if we, as furnace builders, are in a position to recommend one cycle of heat treatment that would be applicable to all steel mills, taking into consideration the variables in chemical composition, conditions of surface, the particular heat gradients to be used with different heat and fuel application and the final end use of the product.

HEATING TIME

The heating portion of the cycle, that is the time in seconds allotted, would be altered by the following:

1. The width and thickness, of strip.
2. The surface, whether bright or dull, which affects the rate of heat absorption by the strip, particularly in the first part of the heating, to say 700 F.
3. The temperature gradient of the furnace, where in the case of gas tubes with good tube life, would not exceed 1800 F, electrical resistors could be safely operated up to 1900 or 2000 F.
4. The particular temper range for which the furnace is designed, whether for T-2, T-4, or TU temper, would also alter the heating time for a given production figure.
   T-2 may require 1350 F top temperature of the strip, whereas TU may well be as low as 1240 F, depending again upon composition, per cent cold reduction and prior steel making practice.

SOAKING

The soak would also vary somewhat, the same as the heating, by reason of the following:

1. The rate of heating, wherein for complete penetration and equalization of temperature through the thickness, a larger soak time may be necessary to avoid over heating, particularly the edges, for a given grain size and physical properties in the end product.
2. The soak section of the furnace cycle is usable as a hold at temperature, or a relatively slow cool through a particular temperature range. Soak in all cases should not exceed 1300 F.
3. Here again, the temper required, whether T-2, T-4 or TU, will dictate the amount of soak necessary in the design, and is consistent with the use for which the major portion of the tonnage is specified. Lower speeds, of course, will permit more soak, slow cool and fast cool time for experimental purposes in the lower temper ranges. A furnace designed specifically for TU temper, at maximum capacity, would necessarily have incorporated in the design cycle, lower top temperature and short soak time.

SLOW COOL

The slow cool to 900 or even 800 F, is considered to be a very important part of short cycle annealing. Carbide precipitation is most active around this temperature.

If sufficient time is not allotted, subsequent aging may increase the hardness, as much as 8 to 10 Rockwell 30-T points. About 12 to 15 sec at the present time, appears to be sufficient for the properties required for TU temper. Some customers, however, have set a higher figure.

FAST COOL

Fast cool from 900 to 450 F is still a function of the type of equipment used, and can be as fast as is practical.

QUENCH

Quench is now being accomplished as high as 650 F, without distortion or discoloration.

Investigation is now being conducted to quench at still higher temperatures, in an effort to shorten the fast cool section.

The foregoing are some of the factors to be considered when designing a strip furnace for a particular customer.

"MECHANICAL EQUIPMENT"

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▲ THUS far in this symposium two papers have been presented which effectively cover the general aspects of the subject and the details of a continuous annealing furnace. When considering a continuous annealing installation, it is logical to place the emphasis on the annealing furnace, as it is the heart of the process and justifiably requires the most serious consideration of all of the economic, operational, and engineering factors that may be involved. Since a continuous annealing line represents a major capital investment, it is essential that it maintain the highest possible degree of its rated capacity. This requires continuity of furnace operation, which in turn depends to a great extent on the terminal equipment responsible for feeding the cold reduced strip to the furnace and receiving it after the annealing cycle.

To date continuous annealing in the steel industry has been utilized in several different strip finishing processes for different types of steel. The highest speed operation has been developed for the very light gage low carbon steel that is utilized in the manufacture of tin plate. Consequently the most complicated equipment problems are represented in a high speed contin-

uous tin plate annealing line; and by comparison the other continuous annealing applications which involve lower speeds and special process requirements do not present as many engineering or operating problems. Therefore, it is the purpose of this paper to submit a hypothetical, high speed, continuous annealing line for tin plate gages.

As is true of most processing lines, there are many minor differences of opinion on equipment design and arrangement among the various operating companies, with the result that what is considered good practice for one producer is not necessarily acceptable to another producer who desires a slightly different arrangement. Consequently the line being presented merely offers a basis on which to comment on various features of mechanical equipment, and is not an attempt to establish an equipment specification that covers all of the operational requirements which exist for various producers in the industry.

The individual components that make up mechanical equipment for such a line are in many respects similar to equipment that is in operation on other strip processing lines, particularly for electrolytic cleaning and electrolytic tin plating. However, in line with the main objective of maximum operating efficiency of the furnace section of an annealing line, additional emphasis must be placed on such features of the mechanical equipment as automation, equipment arrangement for ease of operation with a minimum size crew, rapid coil handling and coil preparation arrangements, provisions for roll changing and roll alinement with a minimum down time, threading aids to minimize downtime, the utilization of dual lubrication and hydraulic systems to permit standby services, and allowances for preventive maintenance during line operation.

For the hypothetical line, let us assume the coils as received from the cold reduction mill are normal tin plate gages and widths, with the coil inside diam being 16½ in., the outside diam approximately 80 in. and the maximum coil weight 60,000 lb. The line speed would be 1500 to 2000 fpm. A 1500-fpm line would represent a higher speed than is obtained on any installation operating at the present time, while 2000 fpm is the design speed of a line now under construction. Although normal tin plate widths are mentioned, the terminal equipment is designed and constructed for strip widths up to 46 in. and on one application 16½-in. inside diam coils weighing 64,000 lb are being contemplated.

Since a continuous annealing line, similar to other processing lines, consists of three basic sections, this line has been separated into entry, furnace, and delivery sections. Referring to Figure 1, the first section is the entry coil handling and strip preparation section embodying the equipment from the coil holders through the cleaning equipment. As depicted, this would consist of No. 1 and No. 2 coil holders with their associated coil storage arrangement, the carry-over pinch roll and table for carrying the strip from the No. 1 coil holder over the No. 2 coil holder, the scrap reel for taking the heavy end material from the leading end of the coils, and the double cut shear for preparation of the leading end of the strip prior to welding.

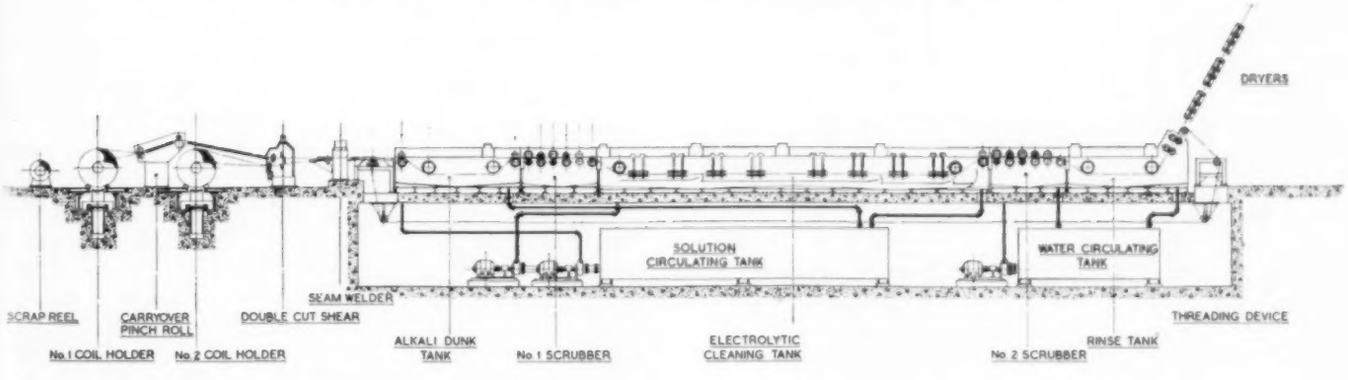
The coil splicing equipment could be any one of several welders which have been successfully used, the most common one being the travel head series seam welder that has been indicated on this diagram. Following the welder is the alkaline cleaning equipment, which has been indicated here as a horizontal type of cleaner, and suitable drying equipment to deliver dry strip to the annealing furnace.

With modern cold reduction mills delivering coils of the tremendous size that are being manufactured by most tin plate producers today, and considering the importance of continual strip flow to the line, the entry and coil handling equipment for such a line becomes a key operation in maintaining efficient production. Coils of this size cannot be rolled without prohibitive damage; therefore, the entry end of such a line might take one of two general forms.

For example, the mill layout might justify the use of a driven pallet or saddle conveyor, which would receive the cold reduced coils from an overhead crane or ram tractor and move them parallel to the annealing line and into alinement with the two coil holders. With such a driven conveyor and with proper sequence control, coil cars equipped with a cantilever lift come between the saddles provided on the conveyor, lift the coils, and transfer them to the coil holder head. This arrangement represents a costly installation, and the conveyors are a source of maintenance, although the frequency of maintenance is relatively low.

The second arrangement, which represents a lesser capital investment, is the coil saddles with a long stroke coil car. This arrangement embodies fabricated steel saddles mounted rigidly in the foundation, on which the coils are placed by overhead crane or ram tractor. The coil car servicing each coil holder has a long stroke traverse cylinder which permits the coil car to come to any position in the line of saddles and move coils to the coil holder head. While a coil is being

Figure 1 — Entry end line arrangement for annealing furnace.



payed off to the line, the car can advance the coils to provide space on the saddles for additional charging. Such an arrangement of coil saddles and long stroke car would be very similar to that shown in Figure 2.

Since the efficiency of the continuous annealing line depends so greatly upon the condition of the cold reduced coils being fed to the line, it is frequently desirable to reject a coil rather than run the risk of encountering difficulties in the annealing furnace from poor tracking, bad edges, or poor strip shape. Sometimes it is not apparent when the coils are delivered to the entry end of the line that unsatisfactory material is present, and it is desirable to have some means of rejecting complete coils, or even the remainder of a coil being run, if this condition develops. To accomplish this, an area suitable for one coil width can be provided in front of each coil holder. The coil car can then remove a coil from the coil holder head and deposit it on a saddle position, where an auxiliary hydraulic ram ejects the coil to a short ramp.

The coil holder for handling heavy coils at high speeds involves design problems which have been worked out satisfactorily in recent years. For example, the use of 16½-in. diam expanded heads for heavy coils results in bending stresses in the mandrel shafts that approach the accepted design limits. This condition is resolved by the use of the highest quality alloy steel forgings to obtain the maximum strength for the small area involved. The small diameter heads have also limited the amount of head expansion that can be obtained within the allowable shaft stresses. Consequently this presents some disadvantages in handling coils which may have a certain amount of cold mill reel break, making them difficult to place on the expanding mandrel.

The use of high speed heads has dictated the necessity of using forged steel head segments designed to have integral wedge gibs, thereby overcoming the possibility of centrifugal forces at top operating speeds literally throwing the segments from the mandrel. The application of chrome plating on sliding surfaces and impregnated lubricated wear strips are all attempts to give heavy duty mandrel construction with minimum maintenance.

Both the No. 1 and No. 2 coil holders would be of the shifting type, arranged for manual shifting by means of either manual or solenoid hydraulic valves. It is entirely possible to use automatic shifting of these coil holders to maintain strip alinement as it is fed to the annealing line. However, with the small amount of telescoping present in the coils received from most cold mills, this is probably not necessary once the coil is properly alined with the centerline of the entry end equipment. If automatic centering of the coil holders is utilized, it should be of the photoelectric or air-jet type rather than the limit travel type, which requires a contact roller riding the edge of the strip. Such rollers can cause tearing of the strip due to the presence of cracked edges.

With the large size coil and the necessity of rapid line acceleration to an over-speed condition, another problem is the selection of the proper type of drive motor for such coil holders. Naturally some of the larger drive motors present many problems in mechanical design, particularly on a shifting type coil holder. In order to obtain the most satisfactory operation on

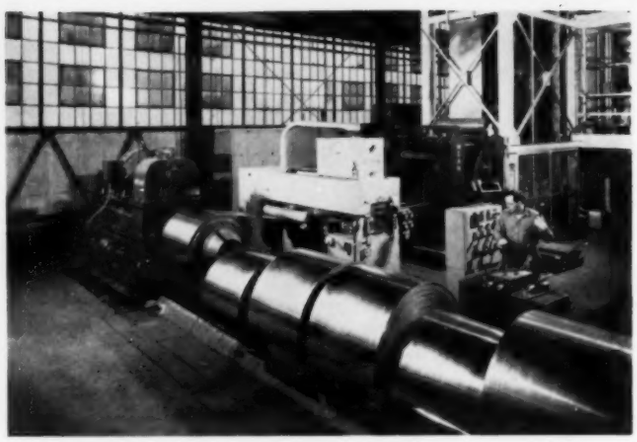


Figure 2 — Coil holders and coil storage saddles.

acceleration of large coils, the selection of the drive motor requires close coordination between the mill builder and the electrical equipment manufacturer.

Another point which can be very important to continuity of operation is the proper design of the hydraulic system. In general, for a line of this type a dual hydraulic system should be installed, which would give one standby pump for a matter of insurance and to permit normal maintenance on the pumping equipment while the line is still in operation. Proper use of check valves, accumulators, and operating valves all deserve serious consideration to give the most desirable operating speeds of the various hydraulic functions, plus the requirement of maintaining proper pressure for the head expansion mechanism.

A scrap or heavy end reel has been indicated, which will permit the operators to recoil off-gage material from the leading end of each coil when it is first mounted on the coil holder head and while the line is operating from the other unit. When the tail end of the coil is reached, this will normally be cut off in either the double cut shear or the welder shear; and once again if a reasonable amount of heavy end material is still present, it may be either back wound on the coil holder and then fed to the scrap reel or it may be coiled manually by the operator and placed in a scrap box. Such a reel would not be an absolute necessity, as it would be possible to feed the leading end of each coil up to the double cut shear and continue to crop pieces until the coil was to gage. The use of a scrap reel has the distinct advantage of forming a coil of the desired size for return to the scrap yard without any appreciable amount of further preparation being necessary.

The double cut shear can be either the motor-operated type or, in the case of the light gage material involved, air-actuated and equipped with feed rolls on both the upper and lower passes preceding the shear mechanism. These rolls are utilized for feeding the leading end of the strip up to the shear head, where the end is cropped prior to the welding operation. After the shearing operation, the end is fed as close as practical to the welder, and is either folded back on the holding table or held by magnets to have the exact length required for placement against the gage bar in the welder when the entry end is stopped for the welding operation. All of these details contribute to minimum welding time, which is extremely important.

In selecting a method of welding, consideration could be given to a travel head seam welder, a lap seam welder, a mash welder, or even a multiple spot welder. For tin plate gages, the welder which has been used almost exclusively on high speed lines has been the travel head seam welder. This is due not only to its lower first cost, but also the fact that it inherently has been a higher speed welder than other methods which have been proposed. The quality of the weld is acceptable, but there is some disadvantage in the fact that there is a possibility of welds tearing loose due to the free edge where the overlap is made.

There has been some criticism of this type of weld on furnace lines from the standpoint that there is always the possibility of water entrapment in the weld which might carry into the furnace. However, the small amount of moisture that is present under such a condition does not appear to be any serious factor, and for the most part has been neglected in the consideration of welding technique.

New design travel head seam welders, where continuity of operation is an important factor, incorporate such minor but important design features as a shifting platen to permit longer operation between dressings of the platen, four-wheel operation for two additional seams where this appears to be desirable from a factor of safety standpoint, and limit switch firing, which ensures that the welding operation takes place only when the wheels are in contact with the strip.

The use of the other types of welders presents some disadvantages, although they have distinct advantages in the type of weld made. For example, the lap seam welder, which has an overlap of approximately one-quarter of an inch, minimizes any problem of liquid entrainment or of the free edge ahead of the weld line. The mash seam welder similarly takes care of these conditions and gives a higher quality weld. The main disadvantages are higher first cost, the problem of satisfactorily lapping such light gage strip, the slower welding speed, and the amount of time consumed to complete a weld cycle. It is necessary to have very accurately sheared edges for obtaining the proper amount of lap and to have the strip accurately alined from edge to edge. This requires special shearing, matching and traversing equipment and more attention from the operator, which results in a longer overall welding time.

The use of multiple spot welders under some considerations would probably be the highest speed weld that could be made. The main disadvantages to this are the lower quality joint that is made, the high first cost of equipment, and the complex problem of cutting out inactive guns when welding various widths of strip. Such a multiple spot welder would be a more complicated design than a travel head seam welder, and therefore a source of greater maintenance.

Considering first cost of equipment, speed of operation, simplicity of strip handling, and weld quality, the travel head seam welder effectively fulfills the requirements of this application.

For such a line, it is normally recommended that a built-in shear be incorporated in the welder for cropping the tail end of the coil. Obviously this saves some feed-up time from the double cut shear; and although it appears to be a duplication of shearing equipment, the few seconds of time saved are very important in the overall operation.

Figure 3 — Entry end of high speed processing line.

What has been described thus far is very similar to the conventional double coil holder arrangement that is used in many strip processing lines, as shown in Figure 3.

In the next step in the entry end arrangement, it will be noted that horizontal type alkaline cleaning has been indicated. This is admittedly an arbitrary selection, but was based on certain design advantages of this equipment as compared to vertical type cleaning that has been practiced in some strip processing lines. The alkaline cleaner of the horizontal type lends itself to this high speed application since it has the advantage of fewer deflector rolls to obtain the desired amount of strip passage in the cleaner; it is a better design to incorporate strip threading devices; it is a better design to incorporate features to cope with the drag-out or solution surge problem; and the design allows for an easier application of a fume exhaust system.

The major disadvantage of horizontal cleaning is, of course, the amount of space it requires. Vertical cleaners have been designed to do the same job satisfactorily at lower speeds. The cost of vertical cleaning equipment would be about the same or slightly less than horizontal cleaning equipment. However, considering the installation and foundation costs, the vertical cleaning might actually result in somewhat lower overall cost, depending entirely upon the conditions for the particular installation. The major point to consider in this question is actual operating experience; and horizontal cleaners have been operated successfully at speeds within the range established for this hypothetical line, whereas no vertical cleaners have been called upon to perform at such high operating speeds. Consequently not quite as much is known about their possible problems of drag-out, sink roll seal and bearing difficulties.

The arrangement shown indicates a pre-dunk tank which serves the primary purpose of cleaning dirt and excess rolling oils that are on the strip, and which are removed entirely by the chemical action of the alkaline cleaning solution during the very brief period the strip passes through this section.

Following the dunk cleaning section is a four-brush scrubber, with each brush operating in conjunction with a steel back-up roll. The scrubber brushes are individually adjustable, actuated by means of air

cylinders through equalizing arms with mechanical stops to obtain the desired setting of the brush and to allow adjustment for brush wear.

Following the No. 1 scrubber is the electrolytic cleaning operation, utilizing a grid to grid cleaning process with low voltage generating equipment to produce approximately 15,000 amp at 18 volts.

One of the major problems involved in such cleaning equipment is the tendency of the strip to pump the solution to the delivery end of the tank at the high operating speeds. This condition is pronounced at speeds in excess of 1200 to 1500 fpm, and definite steps must be taken to counteract this action and equalize the liquid level in the tank; otherwise excessive solution dragout occurs and the grids at the entry end of the tank are soon exposed as the solution level drops.

This can be accomplished in several ways, and in many instances more than one method is utilized, depending somewhat on the operator's preference. A surge tunnel is built into the bottom of the cleaning tank, with scoops located periodically along this tunnel which break up the flow of the liquid to the delivery end of the tank; and due to the differential in head from one end of the tank to the other, the liquid counterflows toward the entry end. At the same time, the practice has been followed of slightly elevating the delivery end of the tank with reference to the entry end, thereby compensating for the difference in liquid head caused by the surge. Another method is to use an external surge line with a high volume pump. This tends to accomplish the desired results, but presents some other problems in creating extreme turbulence at the discharge side of the pump.

Immediately after the cleaning tank is the No. 2 scrubber, which is essentially a duplicate of the No. 1 scrubber and performs the final scrubbing action on the strip. Scrubbers of the type that have been described are shown in Figure 4.

Following the scrubber is located the rinse tank, which can be arranged for either spray rinsing or dunk rinsing, as desired. This serves the primary function of removing from the strip all traces of cleaning salt, and also at the same time maintaining the strip temperature to assist in the drying operation that follows. On the delivery side of the rinse tank are located two sets of wringer rolls. To obtain good strip drying, the wringer rolls must be maintained in good working condition, as any water that is pulled through these wringer rolls will not be effectively removed by the dryers.

The auxiliary equipment for this cleaning section would consist of covers equipped with air-operated lifts to permit rapid opening of the tank for rethreading the strip or maintenance requirements, the solution circulating or storage system provided for the alkali cleaning solution, and the rinse water recirculating system.

A threading device is an important auxiliary to such a line since defects in the strip will frequently result in breakage in the cleaning section. This device consists of a drive on the delivery end of the tank and two endless chains which are carried through the entire cleaning section, following the pass line that the strip maintains in the various tanks and scrubbers.

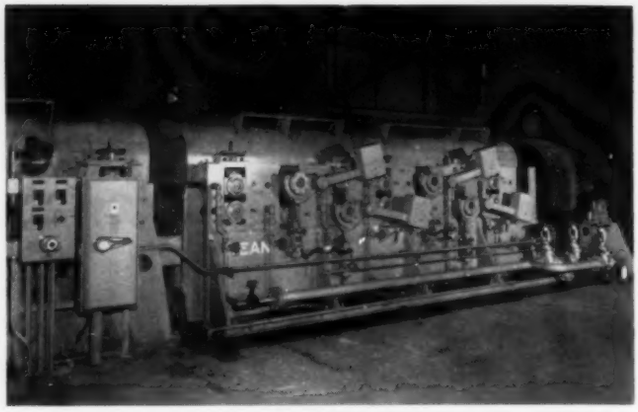


Figure 4 — Four-brush scraper is used for strip cleaning.

Each strand of chain is supported by independent sheaves which are located on the roll necks. When there has been a break in the strip, a threading bar is attached to the chain and to the end of the strip, and the threading device drive is then actuated to pull this threading bar through the tank, thereby reestablishing the pass of the strip through the cleaning section. The strip ends can then be welded together and operation resumed.

Throughout the cleaning section of the line, detailed attention should be given to the design of deflector rolls, wringer rolls, scrubber brush rolls, and back-up rolls to effect the quickest possible changing of these rolls, thereby minimizing downtime for roll changes. At the same time, the necessary features should be incorporated to be certain that, once the rolls are replaced the roll alinement is maintained, since this is such an important factor in proper tracking of the strip.

For high speed operation, two hot air strip dryers would be required to ensure the proper drying of the strip following the cleaning operation. However, a third unit would ensure good drying when overspeeding the entry end to replenish the loops, and give some allowance for operating with only two units if one should be shut down for maintenance while the line is in operation. These dryers are of the conventional type with a low pressure blower and the air heated by means of a steam coil heat exchanger.

The center section of the line would include everything between the two looping means and, of course, the continuous annealing furnace. This is shown in Figure 5. The arrangement consists of the No. 1 tension bridle located on top of the looping pit tower, and Nos. 1, 2, 3 and 4 looping tower pinch rolls followed by the furnace entry bridle or the No. 2 tension bridle, the automatic furnace tension control unit, the furnace, the furnace pulling or No. 3 tension bridle, the exit looping pit tower consisting of three looping tower pinch roll units, and the No. 4 tower tension unit.

The primary function of the looping equipment is to store enough material both ahead of and behind the furnace to permit continuous furnace operation while the entry end is stopped for welding coils or the exit end is reduced in speed to transfer from one coiler to another. The amount of strip storage required is a matter of judgment based on welding time and line acceleration and deceleration time. In most operating installations, the furnace section is reduced in speed

just prior to and during the welding operation, which does not seem to be detrimental to the characteristics of the product, as the furnace responds quickly to the slower speed operating conditons.

For the purposes of illustration, assume approximately 950 ft of effective strip storage in the No. 1 entry loop, which at 2000-fpm furnace speed would allow approximately 28.5 sec for entry end slow-down, welding, and acceleration to speed. This might be feasible considering that present seam welder operations take about 8 to 12 sec, and line acceleration and deceleration could be accomplished in approximately 12 to 15 sec.

Under actual operating conditions, such a short time cycle would not be practical, as very little strip storage

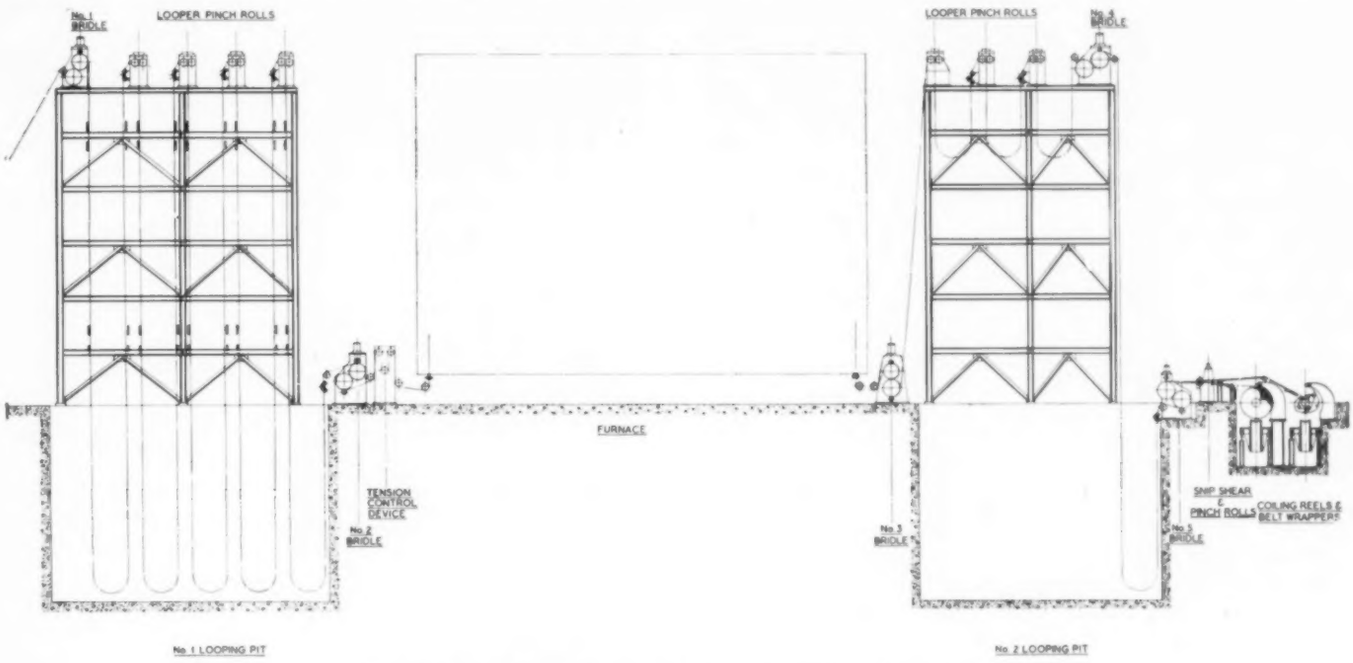


Figure 5 — Arrangement of furnace section and exit end.

would remain in reserve as a factor of safety. By reducing the furnace section and delivery section to a predetermined "welding speed," a cycle of 45 to 50 sec can be obtained. This will allow the operator to decelerate the line at a slower rate to observe the strip condition at the tail end of the coil, which is the portion that is threaded and accelerated through the cold mill and may be material that should be rejected.

As in the case of the electrolytic cleaning equipment for such a line, the indication on this diagram of free-hanging loops was based on an analysis of the advantages and disadvantages of both free-hanging loops and mechanical looping towers.

For a moment let us consider some of the advantages and disadvantages of both systems. So far as mechanical loopers are concerned, their main advantage is the ability to store a large amount of strip in a relatively small area. Although their first cost is not low, it is less than the mechanical equipment involved in multiple free-hanging loops. From an installation point of view, looping towers usually are less expensive than the installation of all the mechanical and electrical equipment for free loops, plus the foundations provided for looping area below floor elevation.

For slower speed installations such as silicon annealing, not requiring such a tremendous amount of strip storage, the mechanical looper or the free-hanging loop of the type indicated are about a stand-off in cost when considering mechanical equipment cost, electrical equipment cost, and the installation of the equipment. This stand-off is overbalanced when a larger quantity of strip storage is required, as indicated for this line.

Looping towers have other advantages in allowing better strip tension control, and they do not involve the problem of strip turn-over and loop sway that is present where long free-hanging loops are used at high speeds.

So far as the disadvantages of a mechanical looper are concerned, one of the main problems has been the inability to satisfactorily drive the rolls. On close analysis it is quite apparent that, when there is any speed differential between the furnace section and the other two sections of the line, the rolls in the looper are turning at infinitely variable speeds in relation to each other. For example, when the entry end stops, the rolls on the delivery side of the looper are turning at the center section speed and the rolls on the entry side are at a standstill. The balance of the rolls are turning at completely different speeds throughout the tower, with some rolls actually revolving in a reverse direction. It has been rather generally agreed that rolls in a line such as this operating at high speed should all be driven with individual drives to prevent marking of the strip, particularly during acceleration and deceleration of the line. This presents a very complicated electrical problem which, to the best of our knowledge, has not been completely solved.

In the past, looping towers have presented a problem from a tracking standpoint, as the slightest misalinement of any one roll in the looping tower may tend to throw the strip off center; and this can be progressively aggravated as the strip passes over the multitude of rolls in the tower. Looping towers require good braking devices for crash prevention in the event that there is a

strip break. This problem has been overcome on more recent installations, as have the problems of carriage swaying, carriage acceleration and deceleration, and looping tower tension control. The looping tower is difficult to thread, but this is probably a very minor disadvantage.

In the consideration of the slack collecting means for continuous annealing lines, some thought should be given to inspection of the strip as it approaches the furnace. Frequently bad strip edges which may result in breaks within the furnace, requiring prolonged shutdowns for rethreading, can be spotted and steps taken to remove these flaws and reweld the strip. With the use of a looping tower, observation of the strip for this purpose is possible on the final pass coming from the tower, but detection at this point makes it very difficult to stop the furnace section in time.

In the case of the free-hanging loops, the main advantages can be enumerated by comparison to the comments already offered on the looping tower. With tension units and tower pinch rolls, there is no particular electrical problem in driving all of the rolls, thereby accomplishing better strip control and minimizing strip marking. With multiple free-hanging loops, suitable guides can be incorporated preceding each looping unit, and the tracking problem is consequently reduced. These were the main factors that influenced our indicating free-hanging loops.

With free-hanging loops, visual inspection of any and all loops is possible; and strip flaws can be detected in sufficient time to slow down the center section of the line and take the necessary action to prevent their entry into the furnace. Crash prevention is not required by the nature of the equipment; and if the strip breaks in the loop, there is a minor advantage in that it is relatively easy to thread the strip from unit to unit across the top of the tower and jog the line to form the necessary loops.

The disadvantages of the free-hanging loops are the higher capital expenditure involved, the amount of space taken up within the building to obtain the desired amount of strip storage, and the problem of strip flop-over and loop sway. The tendency of the loop to turn over has been reduced on some operating installations by the utilization of drag magnets within the tower structure on both the up and down passes of the strip. These magnets serve the purpose of holding the strip in a steady condition, thereby controlling both strip flop-over and loop swaying.

Having considered the advantages and disadvantages the free-hanging loop has been shown; and it is a great deal a matter of opinion or operating practice and experience as to which type of looping device should be incorporated. However, if a looping tower is used, some advantage could be realized by installing another free-hanging loop immediately preceding the furnace, which would present an opportunity to realine the strip prior to its entry to the furnace entry bridle. This would involve an additional bridle in the line, whereas a looping tower alone would not involve any more tension bridles than are indicated for the free-hanging loop system.

As to the individual items of equipment involved, the units are quite comparable to equipment that has been used in the past for similar applications. Tension bridles, for example, are of the offset roll type to obtain the maximum amount of wrap per roll, with each roll driven by an individual motor.

The furnace tension control unit is a mechanism which maintains a constant preset tension on the strip during its passage through the furnace. It consists of two fixed rolls and a tension-controlled, movable roll. The control scheme for the movable roll can be set up using a pneumatic, hydraulic, or torque motor system for presetting tension, and the position of this roll then controls the furnace entry bridle by means of photoelectric position control.

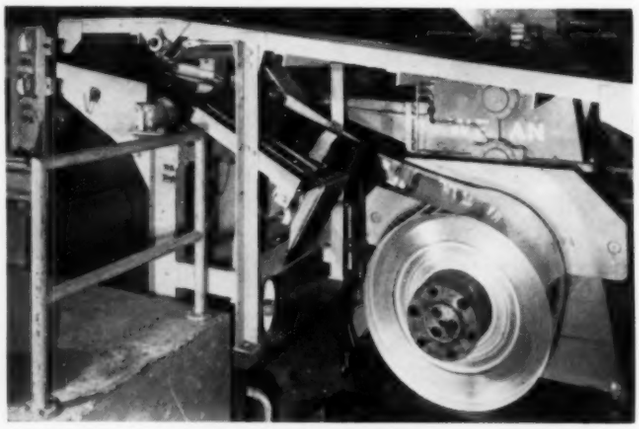
Following the furnace is located the No. 4 tension unit, or main pulling unit, for the purpose of pulling the strip through the furnace. This would also be a bridle with each roll individually driven, the main difference at this point being the type of roll used to withstand the operating temperatures normally encountered.

The exit looping arrangement would be either looping towers or the free-hanging loops as indicated, except that there would be less looping capacity at the delivery end since two coilers will permit transferring from one to the other without stopping the recoiling section, commonly referred to as "on the fly." Thus the large amount of strip storage that is required to compensate for the entry end line stoppage for welding is not necessary at this point.

The exit section or recoiling section of the line consists of the No. 5 tension bridle, transfer shear, carry-over conveyor systems, and No. 1 and No. 2 tension reels with their associated belt wrappers and coil cars. The No. 5 bridle is primarily the same as those described previously, and serves the main function of providing back tension for rewinding tight coils. The selector shear is normally an air-actuated shear which severs the strip material on the fly at approximately 400 fpm, and simultaneously transfers the strip passage from one coiler to the other. The tension reels would be of the automatic shifting type with strip edge scanning equipment which could be of either the photoelectric or air-jet type to ensure straight edge winding of the finished coils.

The belt wrappers have been indicated as the overhung type, but it would be entirely possible to use the vertical type belt wrapper, which is mounted in the pit below the reel head and comes into contact with the head when the car is in the "out" position. Most types of belt wrappers have been successfully employed on compar-

Figure 6 — An automatic shifting winding reel is used.



able operations, and it is primarily a matter of opinion and consideration of first cost as to which type of belt wrapper should be used. The carry-over tables and feeding table to the two reels should be equipped with short sections of driven belt or driven rolls to ensure that the leading end of the light gage strip passes without hesitation to the reel head.

The tension reels have inherently the same design problems and considerations that were previously discussed for the coil holders; that is, the design of suitable heads for the small diameter heavy coils that are involved, plus the design of a proper stripper to ensure rapid removal of the coils from the head. Coil handling on the delivery end of the line once again depends upon the particular coil handling problem at the proposed installation. Coils can be removed directly from the coil cars by overhead crane or ram tractor, or an upender can be installed at this point if it is necessary to transport the coils to temper mill storage with the eye of the coil in the vertical plane. Scales for weighing the annealed coils can be incorporated in conjunction with the coil car operation. The general operation of the tension reels is shown in Figure 6.

The progress that is being made in the industry toward higher speeds and greater production from strip processing lines has increased the scope of such lines. For example, the annealing line which has been described would have an overall length of approximately 520 ft. Approximately 5000 ft of strip would be uncoiled during normal running. Consequently strip tracking is a major factor in obtaining satisfactory operation, and the most up-to-date techniques should be applied for guides, roll shape, dynamic balancing of rolls, tension control and the use of automatic centering devices.

Additional continuous tin plate annealing facilities will be installed in the industry to meet the requirements of new product applications and the increase in consumption due to the growth of our economy. As in the past, the final arrangement of these lines of the future will reflect the result of the combined efforts of the steel producer and his equipment supplier.

"ELECTRICAL DRIVES"

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▲ IN this paper will be considered the special problems encountered in the design and application of electrical drives to the strip propelling means of a hypothetical 2000-fpm continuous strip steel annealing line. It, naturally, will not be possible to completely consider all facets of this subject. Fortunately, however, many characteristics of this electrical drive are similar to those of other continuous processing lines for pickling, cleaning or electrolytic tinning of strip steel. In this paper, it is therefore the intent to briefly review the basic electrical drive which would be recommended for a 2000-fpm annealing line, and to devote major consideration to those differences or special features required for this particular processing line.

In general, the special requirements for a high speed annealing line electrical drive may be segregated into four major classifications.

The first of these is a consideration of the required coordination between entry and delivery section drives to permit introduction and extraction of the coiled stock with sufficient rapidity so as not to affect the speed of the strip through the annealing furnaces.

Second, cleaning of the strip prior to annealing is required and, therefore, steps must be taken to integrate these two functions into a single processing line.

Third, the low tensile strength of the strip steel in the annealing furnaces requires the use of many small helper motors in the cleaning and annealing sections of the line. Coordination and regulation of these helper motors is a major consideration.

And last, methods must be provided to compensate in the electrical drive for changes in strip length caused by the heating and cooling of the steel in the annealing furnaces.

Neglecting for the moment the a-c drives for scrub brushes, spray pumps, exhaust fans, etc., we shall first consider the strip propelling adjustable speed d-c drive.

The basic scheme is shown in Figure 1. Similar to conventional processing lines, this continuous annealing line is separated into three distinct sections; the entry and cleaning section, the annealing section and delivery section. Between each of these sections is a strip looper which provides material storage in the processing line to permit acceleration and deceleration of the entry and delivery sections for coil changes without affecting the speed of the annealing section. Assuming a required coil

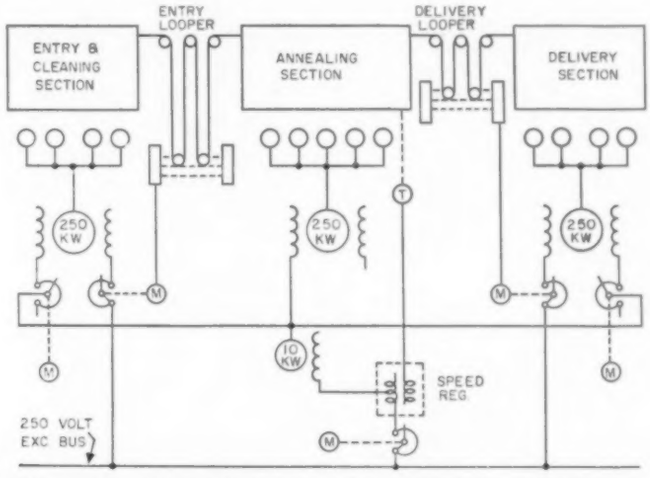


Figure 1 — Basic electrical drive system is divided into three sections.

change time of 60 sec in the entry section, the entry looper on this line would require a storage capacity of 2000 ft of strip.

On the first 2000-fpm annealing line for which we supplied control, there was insufficient room to install an entry looper of this capacity and, therefore, on entry section coil changes it was necessary to reduce the speed of the annealing section. However, since the heat control of the furnace was interlocked to the speed of the annealing section through a rotating cam limit switch on the annealing section speed setting rheostat, this con-

dition could be tolerated without adverse effect on product quality. Nevertheless, in an annealing line it would be desirable to possess sufficient storage in the entry looper to permit operation of the annealing furnace at maximum speed even during entry coil changes.

Figure 1 indicates that each of the three line sections is powered by a 250-kw, two field d-c adjustable voltage generator. The main field of each of these generators is capable of producing rate voltage on the machine and all three main fields are excited in parallel by a master exciter. Through a speed regulator operating in the field of this master exciter, speed regulation is provided in the annealing section. The rate of line acceleration and deceleration is controlled by a motor operated rheostat in the reference field of the speed regulator. A tachometer generator driven by one of the rolls in the annealing section provides a feedback signal to the speed regulator.

In the mian field circuits of the entry and delivery section generators are motor operated rheostats which permit the independent acceleration of the entry and delivery sections. The rotational speed of these rheostats is adjustable from 5 to 15 sec. Although it is desirable to accelerate and decelerate the entry and delivery sections with great rapidity, so as to conserve the amount of strip in the entry and delivery loopers, the large variation between inertias of the individual drives in the entry and delivery sections dictates an acceleration time of at least five sec, and, therefore, the additional expense to provide rapid, current limit acceleration and deceleration of these sections is not justified.

The auxiliary field of each main generator is capable of producing 20 per cent generator overvoltage. On the entry and delivery generators, this overvoltage is used to

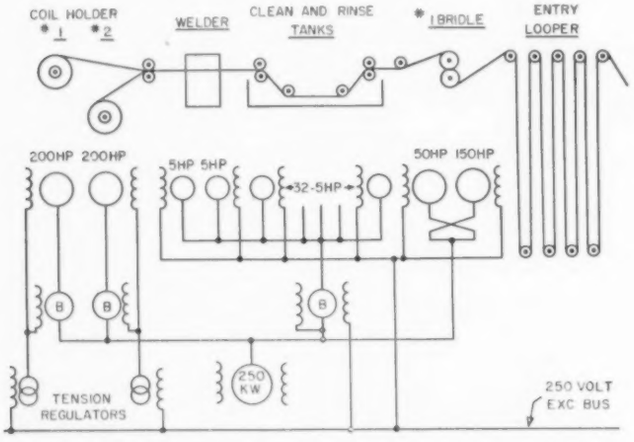


Figure 2 — Schematic shows entry section electrical drive.

overspeed these sections after a coil change to restore the loopers to their normal operating positions. This auxiliary field is not used on the annealing section generator, but is supplied on this machine to make all three generators identical for maintenance and substitution purposes. The auxiliary field excitation of the entry and delivery section generators is controlled by motor operated rheostats whose positions in turn are determined by photo electric limit switches in the entry and delivery loopers.

Figure 2 shows the electrical drive for the entry and cleaning section. The first point to note is the large variation between individual drive ratings and hence the wide variation in mechanical inertias. Normal entry section deceleration is accomplished by returning the motor operated rheostat in the main field of the entry section generator to a low voltage point, and at this low voltage point dynamic braking is applied for final stop. Because of the wide variation in mechanical inertias, a problem arises in maintaining proper strip tension between drives during dynamic braking. For that reason, during dynamic braking only, the generator contactors are opened and the individual motor armature contactors are maintained closed together with the individual dy-

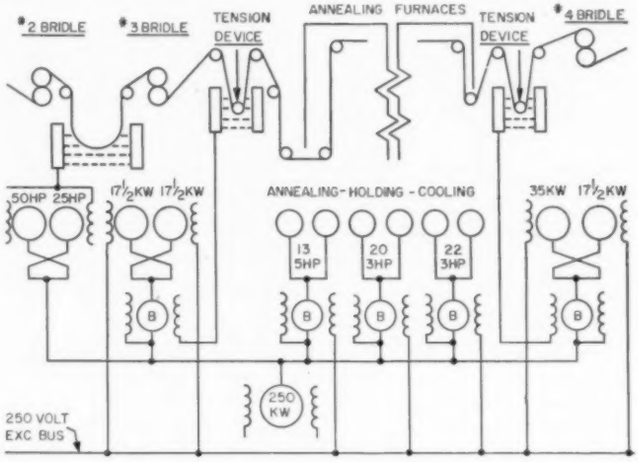


Figure 3 — Schematic shows annealing section electrical drive.

namic braking contactors to provide a common dynamic braking circuit for all motors in the section. This permits the transfer of energy from the high inertia drives to the low inertia drives, thereby maintaining equivalent strip travel on all drives during the dynamic braking stop. On emergency stops, individual motor dynamic braking is used.

The 200-hp motors driving the coil holders have 6 to 1 motor field speed range. This wide speed range is required to accommodate the almost 5 to 1 ratio of outside to inside coil diameter. Due to the amount of power required to accelerate these coil holders with a full coil on the mandrel, these motors are designed to withstand 250 per cent momentary overloads. Each of the coil holder motors is supplied with an individual booster generator and the fields of both motor and booster generator are in turn excited by a conventional rotating type current or tension regulator.

The welder and the cleaning and rinse tanks contain a total of 34 rolls each driven by a 5-hp helper motor. In the welder, these rolls serve as positioning means for the lead and tail ends of coils. They are, however, in contact with the strip during normal operation of the line and, therefore, act as helper drives in propelling the strip through the welder.

All 34 helper motors are connected in series with a common booster generator. This booster generator is of the two field type, one field of which is across a step of resistor in the booster generator armature circuit to provide IR drop compensation to these small motors. The other or main field is connected to the constant potential bus through a manual rheostat on the operator's desk. This rheostat regulates the overall torque exerted on the strip by these helper motors. To insure approxi-

mate load balancing between helper motors, 15 per cent cumulative armature compounding is used.

The protective panels for the individual helper motors will be discussed later in this paper. The system described for the helper motor control in the cleaning and rinse tanks is extremely simple and we believe satisfactory even for a line of this great speed. However, if desired, a current regulator may be added in the main field circuit of the booster generator to regulate total current and hence total torque exerted on the strip by the helper drives. If such a regulator is used, it must be remembered that sink roll drives such as used in these tanks lose contact with the strip at speeds above 400 fpm and at higher speeds a film of solution exists between the strip and the helper rolls. Therefore, the current regulator must possess a voltage or speed over-ride to prevent excessive helper motor speeds during the time the sink rolls are not in contact with the strip.

The No. 1 bridle is the pacer for the entry section. The bridle drive which consists of a 50-hp and 150-hp motor utilizes cross connection of motor series fields to load balance between motors. Proper motor design permits this cross connection even though the motors are of dissimilar horsepowers.

The electrical drive for the annealing section of the line is shown in Figure 3. In this section the major differences between annealing line drives and those of other continuous processing lines are most readily apparent. These differences are caused by the fact that in the annealing section, the tensile strength of the strip is reduced by the high temperatures in the annealing furnaces. Therefore, special measures must be taken in this section to maintain very accurate strip tensions and to eliminate tension build-up in the strip caused by the frictional forces of the mechanical drives.

The No. 2 bridle extracts strip from the entry looper and feeds this strip into a free hanging loop between it and the No. 3 bridle. The purpose of this loop is to establish minimum strip tension to improve strip tracking in the No. 3 bridle and in the annealing furnace. The use of this free hanging loop also divorces from the No. 3 bridle, varying loads caused by changes in the amount of strip stored in the entry looper. The shunt field excitation of the No. 2 bridle roll motors is controlled by a photo-thyratron modulated loop controller operating in the free hanging loop.

Strip tension at both the entry and exit ends of the annealing furnace is controlled by mechanical tension devices which exert given forces on the strip as indicated by the arrows in Figure 3. For the moment, let us pend for further consideration the means by which this force is exerted on the strip and merely assume that a given force is applied to the sink roll of the tension device in a downward direction.

This method of establishing tension in the annealing section is extremely accurate and provides automatic compensation in the electrical drive for changes in strip length due to the heating and cooling in the annealing furnaces. A photo-thyratron modulated loop controller which measures the position of this tension device controls the excitation of the booster generator in series with the No. 3 bridle motors. The speed of the No. 3 bridle motor is therefore automatically controlled to maintain the position of the tension device sink roll in the center of the photo electric loop controller. The booster generator in series with the No. 3 bridle motors also contains an auxiliary field for IR drop compensation. Similarly on the exit end of the annealing furnace, the position of the tension device sink roll regulates the excitation of the booster generator in series with the No. 4 bridle motors. Again this booster generator has an auxiliary field for IR drop compensation.

By use of these tension devices, the group of helper motors driving the rolls in the annealing furnace in essence become the pacer of the annealing section and No. 3 and No. 4 bridle motors are speed regulated to maintain a given strip length between the bridles and the furnace.

In that the annealing furnace used in this type of processing line is of the vertical type, many small looping rolls are required in the furnace to provide the necessary amount of strip travel through the furnace. These many small rolls if not individually driven would cause a very substantial build-up of tension in the strip due to the mechanical friction of each roll. Since the strip in the annealing furnace possesses a reduced tensile strength, it is necessary that each of these looping rolls be individually driven.

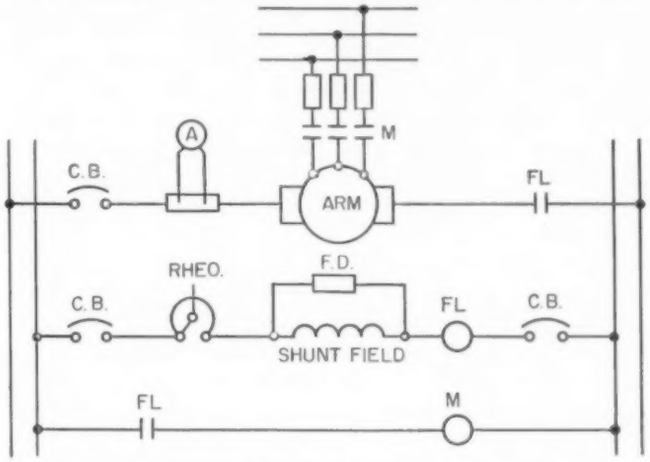


Figure 4 — Schematic shows helper motor protective panel.

In the proposed line, we have indicated 13 five-hp helper motors in the annealing section of the furnace, 20 three-hp motors in the holding section and 22 three-hp motors in the cooling section. Each of these three groups of helper motors is connected in series with an individual booster generator. These booster generators in turn each have auxiliary fields for IR drop compensation, and main fields by which the total current or total torque exerted by the group of helper motors may be controlled manually by the operator. To assist in load balancing between motors, each motor is provided with 15 per cent cumulative armature compounding. As in the cleaning tanks, we again recommend manual torque control for each group of helper motors. If desired, an automatic current regulator could be added to the main field of each booster generator to automatically control torque. Unlike the automatic torque regulator for the helper motors in the cleaning tanks, this regulator need not contain a voltage or speed override control since the furnace rolls are dry rolls and do not lose physical contact with the strip at higher speeds. It should be noted, however, that the higher ambient temperature encountered by the furnace helper motors requires class B insulation on these motors.

In the annealing furnaces it is not satisfactory to assume load balance between helper motors by cumulative armature compounding alone. Due to the lower tensile strength of the strip steel in the furnace, any small variation in speed between adjacent helper motors could cause stretching of the material. Therefore, additional means are required for synchronizing furnace helper motor drives.

A recommended speed matching means is shown in Figure 4. First, note the equipment included on the protective panel for each individual helper motor. This equipment would be the same for the helper motors in the cleaning tanks as well as the helper motors in the annealing section. The equipment would consist of a three-pole, circuit breaker with one pole in one side of the motor armature circuit and one pole in each side of the motor field circuit. In addition, the coil of the field loss relay would be included in the motor field circuit and the contacts of the field loss relay in one side of the motor armature circuit. Therefore, when the circuit breaker is opened, all four d-c leads to the motor would be disconnected. In addition, the helper motor protective panel includes an armature ammeter, a field discharge resistor, and a manual motor field rheostat. This much of the protective panel would be common to the helper motors on both applications.

Additional equipment is then included on the protective panels of the annealing section motors to synchronize the speed of these motors. These motors would differ from the cleaning tank motors in that three points, 120 electrical degrees apart, on the motor armatures would be brought out through slip rings on the opposite end of the motor shaft from the d-c commutator. These slip rings in turn would be connected through a contactor and a set of resistors to a three-phase, bus circuit. For each of the three groups of annealing section helper motors, this bus circuit would then tie together the slip rings of all motors in that group. This syncro-tie would provide the necessary torque to speed match the individual helper motors. The M contactor in the syncro-tie circuit has its closing coil in series with an interlock on the field loss contactor, so that when the circuit breaker in the d-c side of the motor is opened, the M contactor would also disconnect the motor from the syncro-tie system.

Figure 5 shows a typical helper motor control panel. This panel would preferably be located along the annealing line near the helper motors which it controls. At the top of the panel are the armature circuit ammeters and shunt field rheostats. At the bottom are the handles of the three pole circuit breakers. The field loss and syncro-tie contactors, as well as other control components, are mounted inside this cabinet with accessibility through rear doors.

The amount of equipment included on helper motor protective panels is a subject worthy of major consideration in the design of electrical drives for continuous annealing lines. There are approximately ninety small helper motor drives on this line, each requiring a separate protective panel. It is extremely important that sufficient protection be afforded each helper motor within the limitation of economical design.

Figure 6 indicates a suggested means of applying tension in the annealing section through the two tension devices. The tension device indicated in this sketch is the

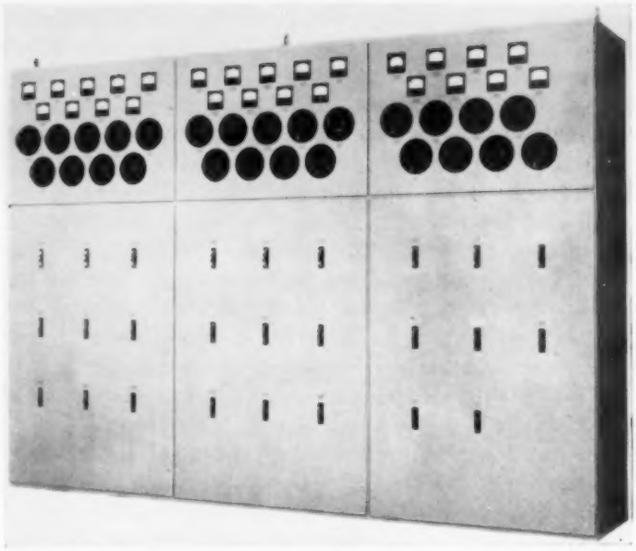


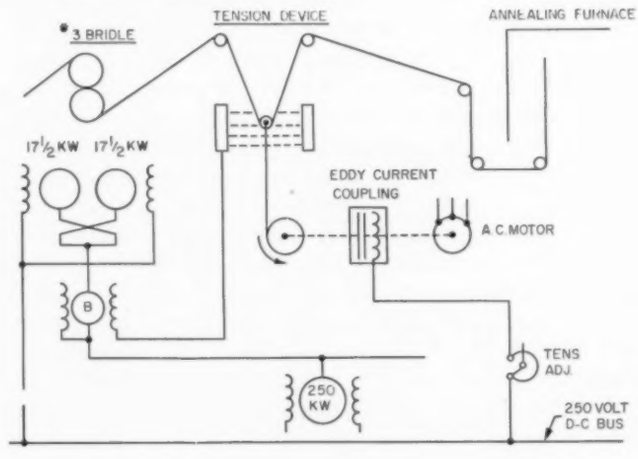
Figure 5 — Helper motor operator's panel for tinning line.

tension device between the No. 3 bridle and the annealing furnace. The photo-thyratron modulated loop controller which excites the booster generator in series with the No. 3 bridle motors has been covered earlier in this paper. The proposed means of applying tension to the strip is to force the tension device sink roll down into the strip by means of an a-c motor driving a capstan through an induction coupling. The amount of torque exerted by the a-c motor on the capstan, and hence the amount of tension exerted by the sink roll on the strip is proportional to the field excitation of the induction coupling. This excitation may be controlled by a manual rheostat on the operator's panel, and or may be automatically regulated to vary the tension exerted by the sink roll under either operating or stalled conditions.

The use of a capstan pulling on the roll is not necessarily the recommended mechanical arrangement, and many other methods could be used. Although the electrical means of exerting this tension may be somewhat more elaborate than the use of either pneumatic or hydraulic cylinders, it does have the advantage of ease of adjustment from the operator's panel and permits a readily adjustable tension range between stalled and running conditions.

The a-c motor and induction coupling system is the

Figure 6 — Two tension devices are used for applying tension in annealing section.



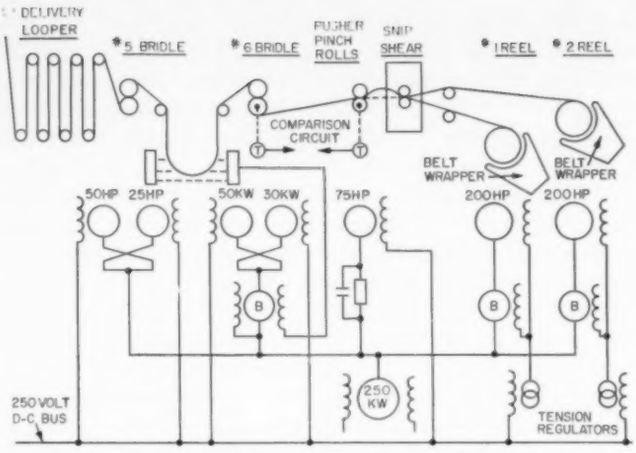


Figure 7 — Schematic shows delivery section electrical drive.

simplest and least expensive of electrical systems. In place of this system, a d-c torque motor with adjustable voltage generator and current regulator could be used.

The delivery section electrical drive is shown in Figure 7 and is similar to the drive for the annealing section in regard to coordination between the No. 5 and No. 6 bridle motors, and similar to the electrical drive of the entry section in regard to the No. 1 and No. 2 winding reels. However, it should be noted that in the delivery section the booster generator excited by the modulated looper controller is in series with the No. 6 and not the No. 5 bridle motor. Although controlling the position of the free hanging loop by means of speed variation of the No. 6 bridle rather than speed variation of the No. 5 bridle imparts some undesirable speed variation to the delivery section, the presence of this booster generator in the No. 6 bridle motors armature circuit provides much better tension control between the No. 6 bridle and the winding reels when accelerating under tension.

The reels in the delivery section differ from the coil holders in the entry section in that they are equipped with belt wrappers. However, the motors are of the same horsepower, the same field range, and have the same 250 per cent momentary overload capacity.

The delivery section differs from the entry section in that it is not necessary to stop the delivery section to change delivery reels. The proposed line requires only that the speed of the delivery section be reduced to approximately 800 fpm for this changeover.

Normally, the pusher pinch rolls located ahead of the snip shear are open and not in contact with the strip. Just prior to a coil change, the 75-hp pusher pinch roll motor is accelerated to line speed by means of armature circuit resistor. The speed of this pinch roll is manually adjusted to the speed of the No. 6 bridle by shunt field adjustment. When the speed of these two devices is matched as measured by two tachometer generators in a comparison circuit, the pusher pinch rolls are closed on the strip. The belt wrapper on the empty reel is moved into position and the empty reel is accelerated to the point that the peripheral speed of its empty mandrel matches line speed. To accomplish this speed matching, when the wrapper was moved into position it tripped a limit switch which converted the normal tension regulator on the reel to a speed regulator. When the empty reel has been prepared to accept the leading edge of the strip, the snip shear is operated.

As the strip is sheared, tension is lost between the No. 6 bridle and the tension reel. The pusher pinch roll then acts as the propelling means for pulling strip through the No. 6 bridle. When the snip shear operates, a flipper gate directs the leading edge of the sheared strip to the empty reel. The strip is accepted by the belt wrapper on the empty reel and sufficient wraps to obtain a firm grip are wound on the reel. As soon as sufficient wraps have been made on the reel, the operator withdraws the belt wrapper. As the belt wrapper withdraws, the limit switch again operates to convert the speed regulator on the reel to its normal role of a current regulator.

This rapid method of material handling in the delivery section of the line permits a major space saving in limiting the amount of strip storage required in the delivery looper.

The entire adjustable speed d-c strip propelling drive proposed for this line can be supported by three duplicate 250-kw, 300-volt d-c generators. These generators in turn can be grouped on one motor-generator set and driven by a 1000-hp motor. In addition, three five-unit booster generator and exciter sets would be required with a total driving motor capacity of 300 hp. Four individual rotating type tension regulator motor-generator sets would be required for the coil holders and tension reels.

The a-c auxiliary drives for scrub brushes, spray pumps, fin mashers, threading devices, etc., would require between 35 and 40 individual motors with a total demand approaching 750 hp.

The motors for the coil holders and tension reels should be forced ventilated to provide sufficient cooling for extended operation at the low end of their wide speed ranges. All other motors could be standard dripproof, protected, 50 C rise machines.

The control equipment for the adjustable speed strip propelling drives would require a panel of approximately 6000 sq ft. Using a standard Class A panel, this would mean a d-c control panel 84 in. high, 50 in. deep, and 86 ft long. The a-c auxiliary motor control could be mounted in a unit type control center and would require a space, 90 in. high, 20 in. deep and 55 ft long. If back to back, unit control center construction were used, the depth of 20 in. would remain unchanged, but the length would be halved.

Preferably the motor generator sets and control panels for this line should be mounted in a control house with a supply of clean air. However, due to the length of this line, it might prove economical to mount the individual section control panels and main and booster generators on the mill floor near their respective line sections. If this would be the case, covers should be provided for the motor generator sets and NEMA 1 enclosures for the control panels. A supply of clean air should then be piped to both the motor-generator sets and control enclosures.

This paper has reviewed the basic electrical drive which would be recommended for a 2000-fpm continuous annealing line. In addition, those design features of this electrical drive that differ from features of drives for other types of continuous processing lines have been stressed. Finally, the paper provides some factual information on the required number and size of rotating machines and control needed to successfully drive a 2000-fpm continuous annealing line.

DISCUSSION

PRESENTED BY

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J. H. Hopper: As these large continuous processing lines are designed for higher and higher speeds, the problem of strip storage in the entry and delivery loopers becomes a major problem both in engineering and in economics. As the author points out, if we assume a change time of 60 sec on the entry section, the entry looper on this line would require a storage capacity of 2000 ft of strip. Obviously, a loop storage facility for 2000 ft of strip becomes very large and expensive. It is believed that an overall economic study of the problem will indicate that it is less expensive to provide more complete automation of the changeover process, including the welding on of a new coil, and thus to reduce the required storage capacity by reducing the time required for the change. Some of the better designed equipments can now change over to a new coil in about 20 sec. If, with complete automation, this changeover could be made in 15 sec. the required capacity of the storage facility would be only 500 ft. This would greatly reduce the size and cost of the equipment.

The particular line under discussion apparently uses the looping tower type of loop storage facility as contrasted with the multiple free-hanging loops. The use of these looping towers considerably simplifies the problems involved in the electric drive system. Multiple free-hanging loops introduce quite a problem for the designer of the electric drive system. However, the use of the free-hanging loops provides a simpler mechanical design.

As the author points out, it is possible further to reduce the capacity of the entry looper by making automatic provision for reduction of the strip speed and the heat input to the furnace while changing coils. This slightly reduces the tonnage output of the line, which introduces another problem in economics.

The speed control scheme illustrated in Figure 1 certainly has some very good points. One of its principal advantages is its simplicity. It is also slightly less expensive than somewhat similar schemes which have been used, with some type of voltage regulator on the entry section and delivery section generators. A debatable question which always comes up, is whether it is better to eliminate regulators or to eliminate motor operated rheostats. A good many users these days apparently feel that it is better to eliminate the motor operated rheostats. This can readily be done without the necessity of using current limit acceleration and deceleration, which also has some drawbacks.

The 20 per cent generator overvoltage is provided on the entry and delivery sections in order to overspeed these sections after a coil change and restore the loopers to their normal operating positions. This is slightly less overspeed than most similar lines with which we are familiar. I believe most of these lines have provision of about 30 to 35 per cent overspeed on the entry and delivery sections. Of course, this is not necessarily all provided by over-voltage. The gearing may be such that normal speed is below rated voltage. The reason given for specifying this amount of overspeed has been to assure ability to fill up the storage loops even when operating with the smallest size coil.

From the description of the circuit given for Figure 2, it is necessary to dynamic brake the entry section to a final stop after having decelerated in response to the motor operated rheostat. One advantage of using a voltage regulator here instead of a motor operated rheostat is the elimination of this transfer to dynamic braking. The regulator can be arranged to regulate right down to zero voltage, and thus stop the drives without dynamic braking. However, dynamic braking for emergency purposes is usually provided, at least on the payoff reels.

I was particularly impressed by the 200-hp motors required to accelerate and decelerate the very large coils in the short time of 5 sec. About fifteen years ago, on some of the earliest continuous processing lines, we had payoff reel drives rated 5 kw. This is a dramatic indication of what increases in coil sizes and line speeds have done to payoff reel drives.

Another notable difference between the most modern continuous processing lines and the earlier ones is the use of more and more small helper roll drives. This particular line has 87 of them.

For the helper rolls which are not submerged in liquid baths, we believe the control scheme described by the author for the entry section is quite adequate. However, there may be some question on the submerged rolls. It has been noted that the effective coefficient of friction between submerged rolls and strip traveling at high speeds is practically zero. When this condition is obtained, a motor with a drooping speed characteristic, or a drive with a constant torque characteristic is likely to accentuate the differences in speed between the strip and the roll, possibly causing scratching by solid particles entrapped in the bath. We believe that the submerged rolls should be treated differently from the unsubmerged rolls. The submerged rolls should have motors with flat speed characteristics, and if regulated they should be regulated with some type of speed regulator rather than with a torque regulator. This will minimize slippage at high speed. We believe that this is a better solution of the problem than a current regulator with a voltage or speed override.

The author states that the method of establishing tension in the annealing section is extremely accurate and provides automatic compensation in the electrical drive for changes in strip length due to the heating and cooling in the annealing furnaces. I have not been able to convince myself that this automatic compensation feature does anything at all. It appears to me that these two tension devices at either end of the annealing furnaces are operating at points where the strip is essentially the same temperature, and therefore traveling at the same speed. These two tension devices control the speed of the No. 3 bridle and No. 4 bridles respectively, but have no control of the speeds of the helper motors in

the heating and cooling zones. These helper motors might possibly vary 1 or 2 per cent in speed between a cold strip and a hot strip, but I would think that this amount of speed variation would be readily absorbed by the drooping motor characteristic, without causing a load variation of more than about 10 per cent. I believe that a more accurate statement as to the function of the two tension devices is that the use of two devices instead of one reduces the possibility of a considerable variation in tension from one end of the furnace to the other due to incorrect compensation of the friction load by the helper roll drives. Even so, it is important that the helper roll drives be adjusted to pull the individual friction loads and nothing more, if considerable variations in tension within the furnace are to be avoided.

The type of tension device described is well recognized and has been used for many years. Its accuracy is dependent on the mechanical friction of the roll position mechanism as illustrated in Figure 6. It can be made quite accurate if great care is taken in mechanical design to keep this friction to a minimum. The electrical manufacturer is here at the mercy of the machine designer. It should be noted perhaps that the control for No. 3 and No. 4 bridle motors are not truly speed regulators, since a true speed feedback signal is not used.

The helper motor protective circuit, as divorced from the synchronizing circuit is very similar to runout table motor protective circuits which have been furnished since 1937.

I regret that I cannot agree with the author in his application of a synchronizing circuit for the helper motors in the center section of the line. This circuit, using slip rings from the d-c motor armature connected to a synchronizing bus will tend to force all motors to operate in exact position synchronism. It seems to me that this is not exactly what is required. Suppose, for example, that the helper rolls are not exactly the same diameter throughout a certain section of the furnace—say the holding section where the temperature is relatively constant. Any difference in roll circumference, however small, produces an accumulative error which will soon increase the phase angle displacement between the various motors to such an extent that the torques will be badly unbalanced and erratic and eventually pole slippages will occur. Furthermore, these variations and reversals of torque will be transmitted entirely through the a-c synchronizing bus, and it will not be readily apparent what is happening by observation of the d-c ammeters. Similarly, in the heating and cooling zones, each of which has a common synchronizing bus, the strip at maximum temperature will run on the order of 1 per cent faster than the same strip at minimum temperature, on account of the change in length due to thermal expansion. This 1 per cent difference in speed is enough to cause a serious unbalance of torques through the synchronizing circuit within a very few revolutions. In my opinion, the problem is not one of synchronizing roll position at all. It is rather a problem of assuring that each helper roll drive delivers just the right amount of torque to take care of the frictional losses in that particular roll. When this is achieved, then the helper roll will neither add to nor subtract from the strip tension.

Assuming that the tensile strength of the strip at elevated temperatures is approximately 8000 psi and that the minimum strip cross section is 0.3 sq in., then the tensile strength of the strip would be 2400 lb. Now assuming that the tension devices are set to hold 1000 lb tension in order to keep well below the maximum limits, it can be shown that the average friction torque compensation provided by the helper motors in the processing section must be adjusted to an accuracy of less than 5 per cent of the motor ratings in order to prevent dangerous buildup of tension or complete loss of tension at some point in the holding section. This is not an easy thing to do. Even if the circuit is designed to regulate current in the helper motors, there is no guarantee that it is adjusted to regulate the right amount of current. One good solution to this operating problem would be to provide a reliable method of reading actual strip tension at a number of points in the line. One method of doing this might be to provide strain gages under some of the roll bearing pillow blocks. It is possible, of course, to design a circuit where this regulation of strip tension could be made automatic. However, it is questionable whether this additional complexity in the circuitry could be economically justified. Perhaps it would be sufficient if the operators could merely read approximate strip tension at a number of points and make manual adjustments on the helper roll drives in accordance with that information.

G. J. Hay: Mr. Fitzgerald has discussed several of the special requirements associated with the electrical drives for a hypothetical high speed continuous annealing line processing steel strip in the tinplate gage range. Each actual line presents its own design considerations for solution by the combined efforts of the steel plant engineers and the engineers of the furnace, mill and electrical equipment builders. In order to round out the electrical equipment builder's views, the following comments are made on some of the points discussed in this paper.

The scheme proposed for coordination of the entry or delivery sections with the furnace section utilizing the master exciter and motor operated rheostats controlling the fields of the entry or delivery section generators is an interesting approach to a problem which presents itself on any line requiring a constant speed in the processing section. It is true that this scheme has an economic advantage over another design such as current limit acceleration and deceleration incorporated in a generator voltage matching regulator. However, let us consider certain operating features which may be deemed to be disadvantages. Assuming sufficient loop storage to maintain constant strip speed in the furnace section during coil introductions or extractions, the time required for acceleration or deceleration of the coil handling sections will be dependent upon the rate of travel of the respective section generator main field motor operated rheostat. In other words, if the rate of travel is the minimum adjustment of 5 sec, then that time of acceleration remains constant for furnace section speeds of 500 or 2000 fpm. Certainly, it would be desirable to accelerate the section to 500 fpm in proportionately less time than that required for acceleration to 2000 fpm. A current limit circuit incorporated in a section generator voltage regulator and based on the section drive having the minimum commutating ability commensurate with drive inertia would provide a constant rate of speed change in the coil handling

section during coil changing operations.

A secondary, but by no means unimportant, effect would be the requirement of variable inertia compensation of the reels. The amount of inertia compensation should be fixed by the coil width and diameter since other components of a particular reel drive inertia may be considered constant. If the rate of speed change varies according to a constant time of acceleration or deceleration, it would be necessary to compensate for this additional variable in the inertia compensation circuit.

It is our understanding that a common dynamic braking scheme is proposed for the entry section drives on all section stop operations with the exception of emergency stops caused by the operation of some machine protective device such as a field loss relay. It is true that the common dynamic braking scheme serves as a means of equalizing the stored energy of the section drives; however, regenerative braking to a low voltage point followed by the application of suicide voltage to the section generator field would be more acceptable. Emergency stops, initiated by the operator, would cause a return of the motor operated rheostat to a minimum voltage point at a faster rate than that for normal stops. The feature of emergency stops by individual drive dynamic braking due to operation of a machine protective device would be retained. If voltage regulators were applied to the coil handling section generators, as previously suggested, strip tensions could be maintained for smooth stops by correct biasing of the regular system.

It does not seem that a discussion of processing line electrical drives is quite complete without some consideration being given to regulating systems. An annealing line of this speed would be expected to be capable of handling relatively large coils. Rates of acceleration, in addition to coil inertia, would dictate special regulator system requirements. Time limitations do not permit a full discussion here on the subject; however, we believe that full consideration should be given to the advantages of the application of magnetic amplifiers to all regulator systems on processing lines in this class.

E. B. Fitzgerald: I wish to thank both Mr. J. H. Hopper and Mr. G. J. Hay for their very fine comments on this paper. I believe the paper and these comments present most of the alternative methods of applying electrical drives to continuous annealing lines.

As Mr. Hay points out, each actual line presents its own design considerations for solution by the combined efforts of the steel plant engineers, the engineers of the furnace, and the mill and electrical equipment builders.

It is my sincere hope that this paper and these comments will stimulate additional thinking on the subject of processing line drives, that will help to develop even better drives for future lines.

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Philadelphia Pa.

▲THE all-basic furnace may be defined as a furnace in which the roof, front and back walls, port ends, downtakes, and at least part of the checker system are constructed of basic brick. The ideal all-basic furnace has not yet been built, but progress toward this objective has been made in America and indeed more vigorous advances have been made in Europe.

For over 15 years the eventual adoption of the all-basic furnace in American open hearth practice has been predicted in numerous publications (1 to 8, incl.)* In 1948 it was stated (2) ". . . The increasing use of basic refractories which has characterized open hearth construction during the past decade has now culminated in the operation of two experimental all-basic furnace applications, both of which are regarded as successful."

This statement in 1948 might be considered highly optimistic since at the beginning of 1956, there were still only two operating all-basic furnaces. However, at this moment, there are six such furnaces in America and it appears highly probable that before the year is over, there will be several more.

We are, in all probability, at the threshold of an era of open hearth furnace construction in which the use of the all-basic furnace will be common. By comparison, the use of basic main roofs now appears to be at the same stage of development as the use of basic ends was in 1946. The first basic end was built in 1943. By 1946, only six such furnaces were being operated by three different companies. From that point forward, increasing numbers of such installations were made each year, so that now there are well over 200 furnaces so equipped. Since the economics of the all-basic furnace are even more attractive than those of basic ends alone, it seems that the pattern will repeat itself at an accelerated pace with a spectacular increase in the use of the all-basic furnace.

In view of this, it seems proper to review the development of the all-basic furnace as we now know it, to consider those factors which have contributed most to its success, and to examine those fields of study where additional improvement would enhance its value still further.

HISTORY OF THE ALL-BASIC OPEN HEARTH FURNACE

The present all-basic furnace stems from two roots, one in America and one in Europe. The developments which took place were at many times divergent. It is only relatively recently that many similarities in the construction, refractories, usage, etc., of the furnaces here and abroad are apparent. Because of this, the two histories are separated in the following descriptions.

Initially, both developments started with the discovery and development of improved basic refractories in the late 1920's and the early 1930's (9–11, incl.). These included the development of spall-resistant refractories, such as chemically bonded magnesite-chrome brick and chrome-magnesite brick in both fired form and chemically bonded, and later, the use of such basic brick clad with thin sheet steel on their principal surfaces. Without these materials, the present all-basic furnace could not exist.

Development of the all-basic furnace in America—In America, the development which culminated in the present all-basic open hearth furnace started with the installation of chemically bonded magnesite-chrome brick in the shoulders of sprung arch roofs of a copper melting, reverberatory furnace at The International Nickel Company, Copper Cliff, Ontario, in 1928. These basic panels extended 36 to 48 in. out from the skews on both sides of the furnace, the balance of the roof being silica. The roof life obtained averaged 140 days as compared with 100 days for all-silica roofs (12). Later, an

* Numbers in parentheses refer to Bibliography at end of paper.

attempt was made on another copper furnace (13) to widen the basic shoulders and construct the entire arch using sprung construction 15 in. thick. However, the arch failed after 37 days due to structural difficulties.

The first large basic suspended arch was applied to a copper smelting furnace at the Hudson Bay Mining & Smelting Co. plant at Flin Flon, Manitoba, in 1932. Chemically bonded magnesite-chrome brick were used. All the roof brick were suspended and steel plates were placed in the joints between individual brick (14). The roof was a success from the start, running 386 days as compared with the average 95 days from sprung silica roofs. During the next few years, the suspended basic roof using unburned magnesite-chrome brick and steel plates in the joints became virtually standard for this type of copper furnace in Canada. This construction was the progenitor of the roof used in the present American basic open hearth roof.

Reports of the excellent results of basic roofs on copper furnaces stimulated discussions in the steel industry (15) and prompted the use of chemically bonded chrome-magnesite brick in shoulder sections adjacent to the skews in sprung open hearth roofs (16). In some cases, this practice has continued to the present. This work also led to the present extensive use of the combination silica-basic or zebra roofs (16–20, incl.) and to occasional use of completely basic sprung arch sections in open hearth port and main roofs. However, this work contributed little to present all-basic furnaces, since the construction techniques and refractories usage of the suspended roof were still to be developed.

The initial trials of suspended basic construction for the open hearth were made by the Bethlehem Steel Co., at Johnstown, Pa. (6, 21, 22), beginning in September, 1940. Two successive roofs with basic panels 11 ft wide extending from skew to skew, were installed. On a subsequent roof campaign, the entire main roof, knuckle to knuckle, was basic. The test was then discontinued, but it was reported (22), "This work took place about the time that business was picking up and we found it inconvenient to experiment further at that time. We are still very much interested in the basic roof and we hope that it will succeed."

The second suspended basic roof trials started at the Ford Motor Co., in February, 1944 (23, 24, 25). These tests continued into 1947 with a total of five basic roofs being tried. They were discontinued with the conclusion that while the basic roof was not justified in the Ford operation at that time, the basic ends were well warranted.

At about the same time as the Ford experiments, Great Lakes Steel Corp. made trials of basic port roofs using construction (26, 27) which was more nearly similar to roof development abroad. The eventual discontinuation of these tests tended to discourage further development along those lines in this country.

In April, 1944, the Steel Co. of Canada started operating an all-basic furnace which continued with only short interruptions through six campaigns over a period of five years. Numerous improvements of design were achieved during this period. H. M. Griffith, A. K. Moore, and others, as well as their company, are to be commended for their notable pioneering work and their published reports of it (28–39, incl.). These tests demonstrated a decided production advantage for the all-basic furnace, although refractories consumption and fuel requirements were not entirely satisfactory. The tests were discontinued in late 1949 as attention was being focused on the installation of a new open hearth shop in this plant.

During the period of the tests at Stelco, interest in the all-basic furnace in the U. S. Steel Corp. led to the installation of an all-basic furnace at their South Works in Chicago, Ill., in April, 1947 (35–41, incl.). This furnace is still operated as an all-basic furnace. It is now in its 24th basic main roof campaign. The operation of this furnace also has contributed greatly to the development of the present all-basic furnace. Many experiments in furnace design, construction and operation have been made during its run.

In July, 1954, an all-basic furnace was started at the Keystone Steel & Wire Co. in Peoria, Ill. (42). Mr. A. H. Sommer has reported on the construction and operating results of this furnace (42–46, incl.). This company's second all-basic installation was made in January, 1956. A third all-basic furnace was installed late in 1956 and the installation of the fourth furnace, to make the shop fully basic, is planned for 1957.

In January, 1956, another all-basic furnace was started at the Inland Steel Co., Indiana Harbor, Ind. (47, 48). During 1956, plans for the conversion of three more furnaces to all-basic construction were made. Two of these, one located at the Laclede Steel Co., Alton, Ill., and the other at Jones & Laughlin Steel Corp. in Pittsburgh, Pa., are now being converted. The third such furnace is located at the Armco Steel Corp. at Middletown, Ohio.

Thus, there are presently a total of nine all-basic furnaces in five different companies' plants, operating or scheduled for conversion. The installations of several other all-basic furnaces are being considered.

Development of the all-basic furnace abroad—Earliest development of all-basic furnaces in Europe started with trials of basic shoulders and combination basic and silica roofs similar to many American arrangements now used. These preceded the first trials of sprung all-basic main roofs in Germany and Austria in 1932 (49) using a fired chrome-magnesite brick. Later, a construction was developed using suspended rib sections with intervening valley sections which were sprung from skewbacks. This type of roof is still the one most widely used in Europe, although recently the use of fully supported roofs has begun.

By 1935, some 15 all-basic roofs had been shipped (49). In 1937, 33 roofs were shipped; in 1938, 290 more were shipped, etc. In the ten years after 1940, over 1,000 basic roofs were supplied. It is not known how many different all-basic furnaces were involved. Partial basic roofs, similar to the German and Austrian furnaces, were also tried in Australia (50, 51) and England (52, 53) during the late 1930's.

By the end of the war, it became known that the all-basic furnace was in wide use throughout Europe (54). After the war, the numbers of basic furnaces in Europe decreased to some extent because of supply difficulties. However, early this year it was reported (45) that there were 208 basic roofs on the existing 537 furnaces in 13 countries in Western Europe. Until 1950, all of the basic furnaces in Europe were built without the use of suspended basic ends. Considerable difficulty was experi-

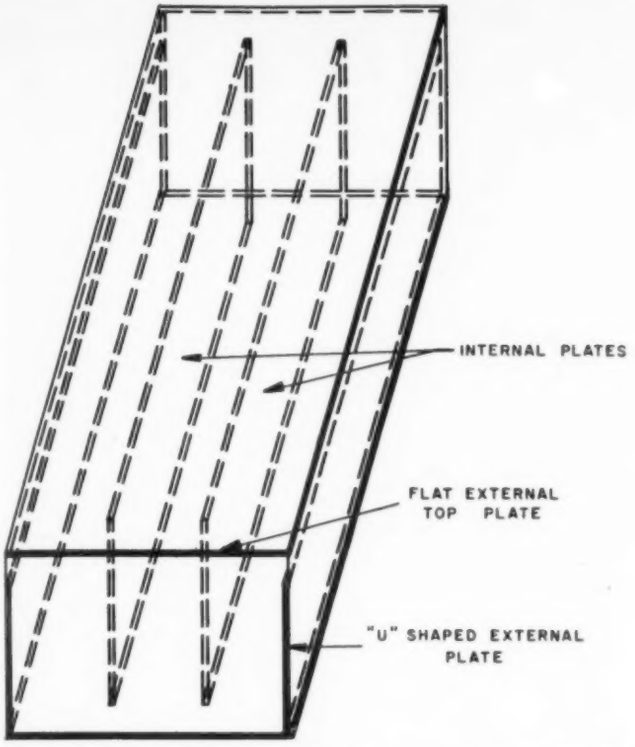


Figure 1 — Sketch shows plating arrangement of brick with internal plates.

enced in maintaining the silica structure used to support the ends. Since 1950, the use of suspended basic ends, following American practice, has been widespread. Most of the existing furnaces have been rebuilt with suspended basic ends and all new basic furnaces use the suspended construction.

It is also interesting to note that in the early development of the all-basic furnace in Europe, the basic brick did not meet all the economic expectations in comparison with silica. To achieve successful operation, it was necessary to develop furnace designs, bricklaying practices and operating procedures compatible with the new material. Some of these changes include additional water-cooling of the front walls, gas ports, skewback channels, etc.; the use of archless doors, provision of proper expansion allowance, and many other changes similar to those instituted in America.

REFRACTORIES FOR ALL-BASIC FURNACES

The refractories practice for all-basic furnaces progressed along different paths in Europe and America, as did the overall development. In both places, satisfactory basic refractories for the main roof have been the major concern in the development of the all-basic furnace.

Basic refractories for open hearth roofs—In Europe, the brick most mentioned is a burned chrome-magnesite brick (7, 8, 15), similar to several American standard brick (4).

Trials of the European brick in this country, both before and since the war, have repeatedly shown no difference between them and similar American products. This result has been verified enough times to allay the often made suggestion that the explanation of the earlier success of the European all-basic furnace was better refractories.

The conventional chrome-magnesite roof brick in Europe has not been provided with attached steel plates. The brick have normally been laid with thin, loose steel plates in the joints running across the furnace, and with wire screen or gauze in joints between brick in the rings. The use of plated, chemically bonded brick, according to American practice, is now being used extensively in European furnaces. From early results, it appears that this practice will gain in favor. This is the first major change in refractories for European basic roofs since the early trials.

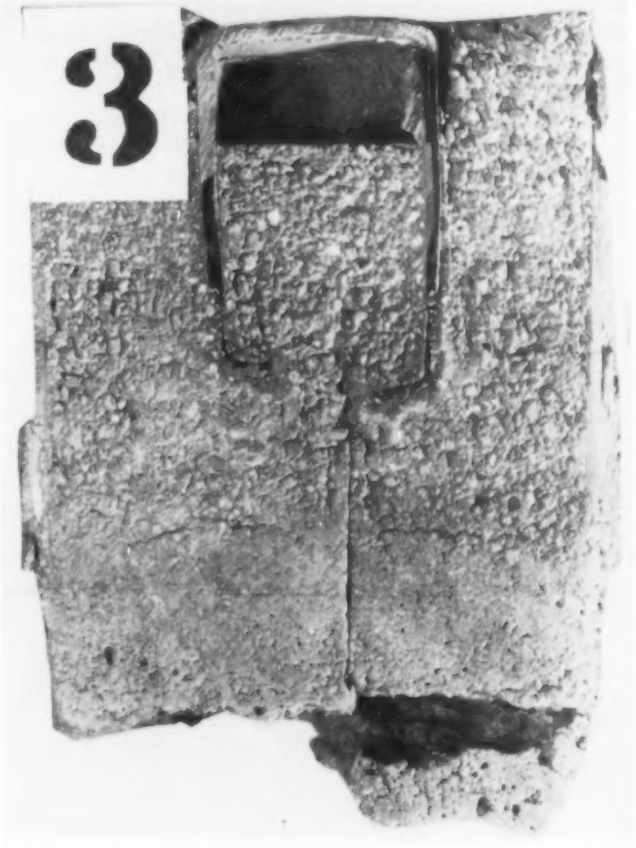
In America, the first basic panel installed in an open hearth roof was made up of chemically bonded, chrome-magnesite, steel-clad brick (55) especially designed for roof service. Since then, this same brick has been used in roughly 90 per cent of the basic roofs installed thus far in America.

At least 20 other basic brick, burned and unburned, domestic and foreign, varying in chrome-magnesite ratio from 1 to 10 to over 4 to 1, of different grinds, bonds, and with wide variation of chemical and physical properties, have been tried in comparison with the first used brick. In every comparison to date, the composition used in the original trial appears to have come out ahead.

While the composition of the refractory materials has remained relatively unaltered, the results from the use of the all-basic furnace have changed drastically to successful operation and a bright future. This indicates that much improvement has been added from sources other than improvement in the properties of the refractory materials themselves.

However, there has been one major change in the

Figure 2 — Cut section of used basic roof brick shows normal cracks.



properties of the brick which has helped make this record. This change affects only the design and plating of the brick rather than the refractory materials (56).

Originally the brick were clad with steel on the four principal surfaces. Thus, the brick cross section exposed to the furnace was 4½ x 3½ in., the full width and thickness of the brick. Starting in 1949, trials were made with brick which, in addition to the plates on the four principal faces, contained a plate embedded in the brick body. This plate extended longitudinally through the brick so that each brick was, in effect, made up of two half brick. The exposed cross section of individual refractory sections of this brick was only 3½ x 2¼. The results of these trials were sufficiently encouraging that the brick with the single internal plate was widely used in American tests.

In 1953, a brick containing two such internal plates which divided the brick into three sections, was tried in a roof panel and compared with the brick with a single internal plate. This new arrangement of plates presented an exposed refractory cross section of only 3 x 1½ in., as shown in Figure 1. The result of this change was startling. At the end of a full roof campaign, when the single internal plated brick were completely worn out, having a thickness of from 0 to 3 in., the test panel of double internal plated brick was 6 to 10 in. thick. Subsequent trials of full roofs of the double internal plated brick gave correspondingly increased life, and further split roof tests verified the original results.

Before the double internal plated brick were used, basic roofs gave about twice the unit roof life of silica. With double internal plates, the ratio of roof life jumped to about three or more. This improvement was sufficient to lower basic roof refractory costs so that they became equal to, or lower than, those of silica roofs.

In retrospect, the explanation of this result appears simple. For years, the spalling or peeling of basic brick has been noted and recognized as the major cause of basic roof wear. Examination of used brick showed incipient cracks from ½ to 2 in. behind and parallel to the hot face, as shown in Figure 2. The development of these cracks is the forerunner of the peeling away of the hot face. This action has been discussed at length (7, 24, 57, 58). However, it is only recently that the cracking has been demonstrated to be principally the result of reversible thermal expansion. Such cracks can be produced in the laboratory merely by repeated heating and cooling of one end of the brick.

Figure 3 is a diagram which illustrates this action. The bold lines represent a basic brick as installed in a furnace before heating. The lighter solid lines show an exaggerated view of its shape when the furnace is hot and a uniform temperature gradient through the refractory has been established. The corners of the brick at the hot face have moved from positions A and B to A-1 and B-1, respectively. The amount of movement is dependent upon the expansion coefficient of the brick material, the temperature rise and the distance between A and B.

Assuming that positions A-1 and B-1 represent the condition of the brick at tap, within a few minutes, during charging, the furnace temperature will have dropped sharply. The hot face corners of the brick then try to assume the positions represented by points A-2 and B-2. However, if a thermocouple were measuring the temper-

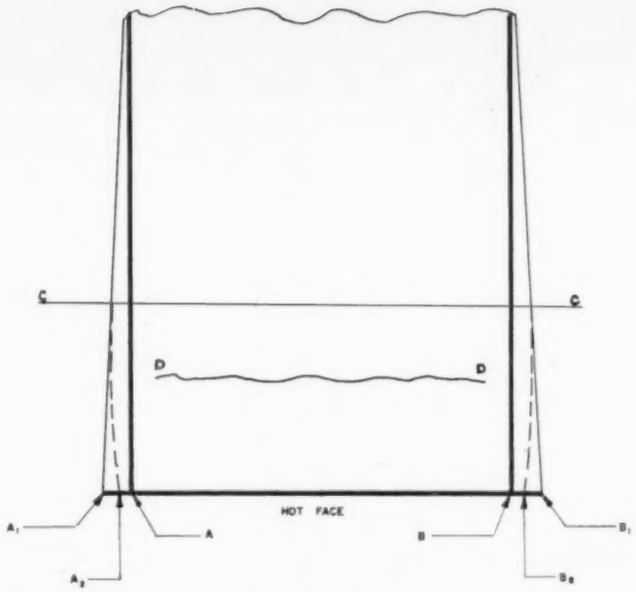


Figure 3 — Schematic diagram shows effect of reversible thermal expansion on a basic brick undergoing temperature changes.

ature of the refractory at some position along the line C-C, little or no temperature change would have occurred, because of the lack of time to establish equilibrium conditions. Thus, the edges of the brick at this level would have moved inwardly very little, or not at all. In this event, the hot end of the brick must try to assume the shape represented by the dotted line between points A-2 and B-2 and the edges of the brick at line C-C.

This action when the furnace temperature drops, or its reverse when furnace temperature rises, obviously sets up severe stresses within the brick body. These can be alleviated to some extent by the formation of a crack along line D-D, or such as that shown in Figure 2. When the crack extends itself and finally reaches the edges of the brick, the whole brick section ahead of it is free to peel away.

The effectiveness of decreasing the size of the exposed brick end on service life is striking. For example, in a split zebra roof test of double internal plated brick using 6-in. wide keys in one-half of the roof and 4½-in. wide keys in the other half, the smaller tile outlasted the larger by over 25 per cent. This result occurred when the decrease in size of the exposed refractory end was only from 3 x 2 in. to 3 x 1½ in.

In addition to the effect of the smaller refractory faces, the presence of steel sheets embedded in the refractory, is helpful. The steel oxidizes in service and the iron oxide is absorbed by the refractory. This reaction appears to inhibit the development of spall cracks, as can be seen in Figure 2. Figure 4 shows this also in double internal plated brick. It will be noticed that while some cracks and fissures do occur in the double internal plated brick, they have less continuity, so that there is much lesser tendency for spalled pieces to peel away.

Figure 4 also shows that the oxide from internal plates behaves more advantageously than the oxide formed from external plates. The internal plate is in intimate contact with the magnesium oxide present in the

Figure 4 — Cut section of used double internal plated basic roof brick.

refractory. In service, oxygen diffuses into the brick and combines with the metallic iron at the surface of the plate. The oxidized iron reacts with magnesia, forming magnesium-ferrite, $Mg{\cdot}Fe_2O_3$. This compound has two desirable properties. It is quite refractory and it forms a solid solution in crystalline magnesia which is still more refractory. No expansion in the volume of the brick occurs due to the oxidation of the internal plates.

External plates in the brickwork joints expand upon oxidation, because only part of the plate surface is in contact with magnesia. The surfaces not in contact with magnesia do not form magnesium ferrite, and as a result, are only partially absorbed by the brick. The unabsorbed oxide forms a layer which is much thicker than the original steel. This section can push adjacent bricks apart and cause an entire roof to grow. This can cause some structural difficulties in basic installations. Internal plates do not cause such effects.

Trials of internal plated brick in roofs in Europe in comparison with their normal practice, have demonstrated the advantages of the internal plated brick. In one instance, burned chrome-magnesite brick ribs were used with internal plated brick valleys. The valley brick protruded from the hot face of the roof throughout the furnace campaign. With all burned chrome-magnesite brick, about 750 heats to the first patch and about 900 heat campaigns were normally obtained. The partial internal plated roof gave over 900 heats to the first patch and a total campaign of over 1250 heats. Further trials of internal plated brick in Europe are in progress.

Recently a further improvement in internal plating has been developed. The original double internal plated brick were suspended by means of a hanger which engaged a recess or hole molded in the cold end of the brick. Because of this hanger recess, the internal plates terminated about three inches from the cold end of the brick. When the brick became thin, a crack developed at the end of the plates and the hot face of the brick was lost. The defect can be corrected by making the internal plates extend practically to the cold end of the brick. This requires making the hanger recess smaller to fit between the plates.

The use of the internal plated brick is not limited to the roof. Trials in other locations have also yielded superior results. Internal plated basic brick can be expected to improve the life of all structures in which spalling or peeling of the brick is the major cause of wear.

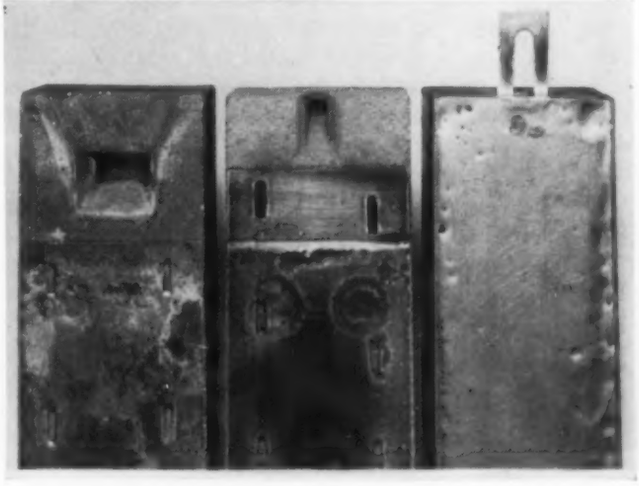
Internal plated brick do not improve resistance to chemical or slag attack, although in some instances they may permit the use of a more chemically resistant refractory, for example, a composition higher in magnesia, that otherwise would be unsatisfactory because of spalling. Double internal plated brick represent a tremendous stride forward in the development of basic refractories, but they cannot be regarded as a panacea for all basic brick problems.

Another item of brick shape which has contributed to increased life and lower costs of suspended basic roofs concerns the provision for attaching a hanger to the brick. Figure 5 shows three brick with different hanger accommodations.

The brick at the left consists of a socket within the brick body that will accept a hanger casting. This type has been used in several American basic roofs.

The brick in the center has a socket at the extreme end of the brick. This socket is closed at the top by means of a steel clip pressed into the brick body. Thus, only slightly over one inch of the refractory thickness is used to provide support and more wearing refractory is available. This type of hanger accommodation has been

Figure 5 — Three hanger accommodations shown are used for suspended basic roof tile.



widely used in basic roofs in America, and has also been used extensively in suspended basic end structures both here and abroad.

The brick on the right in Figure 5 shows a means of hanger accommodation which permits the full thickness of the roof to be usable refractory (61). In this arrangement the steel casing is provided with an angle of stainless steel so that one flange of the angle or tab, in which a slot has been punched, lies along one end of the brick. The brick is manufactured and shipped with the tab in this position, but when ready for installation in the furnace, the tab is bent up to the position shown in Figure 5.

The attachment of the tab to the brick is not dependent on the external plating. The metal from the punched slot becomes a finger or lug which is molded into the brick body. This alone is sufficient to carry the weight of the brick.

The advantages of the tab hanging arrangement lie in the additional usable brick provided. Tab brick also are easier to use in patching. Two tab brick hang automatically from one hanger without wiring or strapping them together.

The first tabs were made of common steel. Near the end of the runs of these roofs, some difficulties were encountered from oxidation of the tabs. Since then, to avoid oxidation, the tabs have been made of stainless steel and no difficulty has been experienced. The economies provided by the greater usable thickness with tab brick are favorable for roof construction. Some designs also incorporate their use in basic ends and other supported walls.

Summarizing this discussion of basic roof refractories, there now are available basic brick which yield good service. Some further improvements may be possible in roof refractories, and experimental work of this sort is in progress. However, there is no need to wait for further development of refractories before capitalizing on the advantages of the all-basic furnace.

Refractories for front and back walls—One of the more troublesome refractory areas in the all-basic furnace has been the front wall. This area must withstand severe slagging conditions in the lower sections, moderate to severe spalling conditions in the upper section, and severe mechanical abrasion. Of these, the slagging condition which causes undercutting, appears to be the worst offender.

To date, no refractory has been found which will withstand front wall service in all-basic furnaces without assistance. Such assistance is possible through judicious use of water cooling. Water-cooled coils or cooling boxes, properly spaced in the lower sections of the wall close to the slag line and in the splash area, can double or triple front wall life.

This practice is recommended for all-basic furnaces. It is commonly used in Europe and has found application in virtually all of the all-basic furnaces in this country. Water-cooled skewbacks and, in some cases, in the upper parts of the back walls, have frequently been found advantageous also.

When water-cooling is not used, the extensive use of relatively heavy ($^3/_{16}$ to $^1/_4$) steel plates in every bed joint, or in alternate joints of both front and back walls, frequently improves life. When this is done, the plates extend outward from the cold face of the wall to tie with the furnace frame. They then act as radiators to cool the wall. They are not nearly as effective as water-cooling.

The refractories which serve best in front and back walls, with or without the cooling described, are of the chemically bonded, plated, magnesite-chrome or chrome-magnesite varieties. Double internal plating of brick has improved life in a few cases, but in these areas it offers little advantage in resistance to slag action. Water-cooling is recommended for the front wall piers of all-basic furnaces as the most likely solution to this problem.

Refractories for basic ends—Other than the rapidly increasing use of internal plated brick in basic end, suspended and unsuspended sections, the refractory usage in basic ends has not changed for some time. A few plants prefer burned chrome-magnesite brick for some portions of the suspended sections, but over 80 per cent of the suspended brick in basic ends are steel-clad, chemically bonded, chrome-magnesite or magnesite-chrome brick. The same brick are used almost universally in the unsuspended sections. In a recent comparison, such brick in the end walls above the floor, were in good shape after 250 heats and were continuing in service, while on a similar furnace in the same shop, burned chrome-magnesite brick had to be patched before 200 heats, and completely replace shortly thereafter. Overall, including both suspended and unsuspended brick, it appears that well over 90 per cent of basic brick in end structures are of the unburned, plated variety.

Refractories for checkers—Any discussion of all-basic furnace refractories would not be complete with out mention of basic checkers. This is a relatively new field for basic refractories. The use of basic checker brick began in glass melting tanks in 1933 (59). The basic brick were much superior to the siliceous material formerly used. As a result, the ports, checker chamber and checkers themselves have become basic for most glass tank usage. This has led to the use of basic checkers in European glass plants. Extensive trials, both in Europe and the United States, are in progress for open hearth regenerators (60, 61, 62).

From experience to date, it appears that basic brick pay for themselves in the upper courses of regenerators where fireclay brick are rapidly fluxed or melted. However, greater advantage is possible through re-design of checker systems utilizing the properties of basic refractories, to obtain higher air preheat. This subject is discussed further in a later section.

Almost any basic brick appears to give good service in checkers if the temperatures are in the low range. At higher temperatures, however, reaction between iron oxide dusts and chrome ore can cause growth of the chrome grains and set up forces which can cause failure of brick containing chrome. When temperature fluctuations are great, burned brick that are too hard and strong tend to crack into cubes because of their difficulty in adjusting to size changes caused by thermal expansion and contraction. Yet, brick which are soft and punky are difficult to rehandle after use.

Many regular and experimental brick are being tried. Most of these have been selected for trial on the basis of compromise between various of the above-mentioned wearing characteristics. Several of these

brick show promise, but the brick which will best meet the variety of conditions in different checkers, has yet to be determined.

Such a brick is apt to be a chemically bonded brick of high magnesia content free of or low in chrome content, and so bonded that it will have sufficient strength after heating to permit handling, but sufficiently low in hot strength that its rigidity will not cause it to crack up under constant thermal changes. Brick intended to have just such properties are under test, but further experience is needed to demonstrate their advantage.

THE CONSTRUCTION OF ALL-BASIC OPEN HEARTH FURNACES

Any structure should be designed according to the attributes and limitation of its component parts. When the material used to make the structure is changed, frequently the design should be changed also. Sometimes, different designs will work, but usually one design is better suited to fulfill the requirements.

This is the present situation in basic roof construction. Some five different designs have been developed and are presently used. At first glance they appear radically different but, upon study, it is found that each provides certain critical structural characteristics which are essential to the use of basic refractories. However, some of these designs work better than others.

To compare the various structures, it is necessary to list the critical features they must provide. These items of construction have been identified as progress has been made in design development. Some were discovered fairly recently and were not considered in earlier developments. Therefore, instead of presenting a chronological story of design development, the features, believed to be necessary in good basic furnace design, are discussed without reference to their discovery. Subsequently the various designs presently used will be compared as to their capabilities for meeting the requirements.

Principals of good design—Any open hearth structure must be capable of easy erection and repair. In addition, for basic furnaces, the structure should provide for a minimum of compressive force applied to the refractories and a minimum of movement of any given point on the hot face of the refractory. This can be done by proper use of suspension, by elimination or minimization of corbels, by providing proper expansion allowance and proper provisions for roof growth which results from plate oxidation in the joints.

Suspension—Suspension is helpful in basic open hearth roof construction to help carry the greater weight of the refractories and to prevent the thrusts developed by this weight from being applied to the hot face of the brick. However, if the thrust can be confined to the cold part of the brick structure, the suspension can be eliminated. Because of this, the suspension of every brick is not a requirement. This is particularly true in furnace ends where suspension is used as much for design advantages as for structural reasons. With basic roofs, complete suspension offers several advantages both in supporting the brick so that there is little roof thrust and insuring that the roof will not fall in. Partial suspensions provide the required support but do not offer equal insurance of structural stability. The

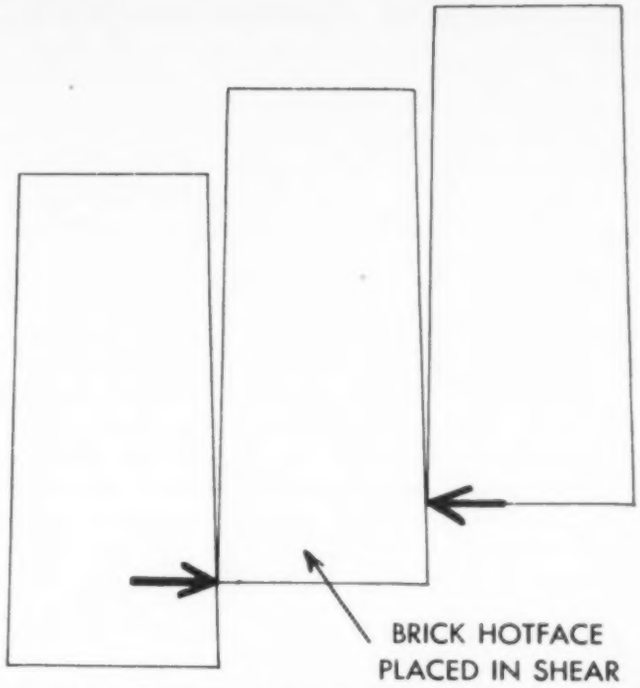


Figure 6 — Exaggerated diagram shows shearing stress resulting from thermal expansion in corbelled sections of a basic roof. Arrows show forces resulting from thermal expansion.

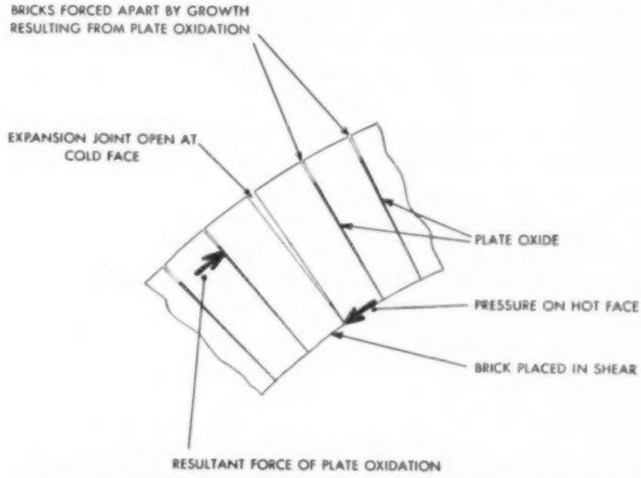

BRICKS FORCED APART BY GROWTH RESULTING FROM PLATE OXIDATION
EXPANSION JOINT OPEN AT COLD FACE
PLATE OXIDE
PRESSURE ON HOT FACE
BRICK PLACED IN SHEAR
RESULTANT FORCE OF PLATE OXIDATION

Figure 7 — Exaggerated diagram shows shearing stress set up by expansion joints in basic arches.

slightly extra cost of full suspension over partial suspension arrangements is more than warranted for all large roof installations.

Corbelling—Corbels on the hot face of a structure cause shearing stress to be applied to the hot end of the corbelled brick. Figure 6 shows a schematic diagram of this action.

The ideal arrangement would eliminate corbels completely. This can be done across an arch by using key-shaped brick in a true radial arch shape. However, some corbels are occasionally necessary along the length of the furnace. When this condition exists, the corbels should be of minimum possible size. In this connection, it should be mentioned that arched roofs built on centers have much more uniformity of surface than do those which are hung from the furnace steelwork without centers.

Expansion—The importance of the effects of ther-

mal expansion and contraction on individual brick has already been described. It is only logical that the cumulative effect of these movements should also have major effect upon overall life.

The best arrangement for expansion allowance would provide necessary space for the expansion of each brick. In addition, it would provide for the difference in expansion at the hot face and the cold face of each brick. However, such provision would be so elaborate that it would be impractical. Another requirement is that the expansion allowance should not be overly large This is necessary to prevent gas flow through the joints. Also it has been found that too large joints cause rapid wear.

Expansion provisions have been made in a number of ways which vary in approach to the ideal arrangement. One extensively used expansion provision has been the so-called "block" arrangement. Expansion joints about ½ in. wide, filled with spacers to decrease air or flame penetration, are provided about every two feet in both directions for a total allowance of about 2 per cent. Figure 7 shows a schematic diagram of the closing of such a joint. Note that only the hot end of the joint closes. Thus, any pressure exerted on the roof must apply at the hot face where the brick is weakest. Another disadvantage of this type joint is that the brick adjacent to it must be moved a comparatively substantial distance to close the joint. This amount of movement of the hot face without corresponding movement of the cold face can easily cause tearing and peeling of the hot face. In view of all these things, if block joints are to be used, many small joints are preferable to a few larger ones.

Another type of expansion allowance is provided by inserting wire gauze between brick in a ring across the furnace. The mesh size of the gauze is usually about ¼ in. and the wire diameter is about 0.04 in. The gauze replaces sheet steel in the joint and serves other purposes besides providing for thermal expansion. However, the expansion allowance it provides is an important part of its function.

The full joint thickness is double the wire diameter. However, the points at which the wires cross cover a very small area of the joint. In service, the wire oxidizes. The oxide melts out of the joint near the hot face. Behind this area in an intermediate zone, the oxide at points where wires intersect can crush to provide for expansion. Meanwhile, the unoxidized portions of the gauze near the cold face maintain the joint at full thickness. This type joint fulfills its function in permitting expansion, but the absence of the steel sheet from the joint has been harmful to refractory life.

A third type of expansion provision for basic roofs to be used in the transverse direction across the arch is the use of double water-proofed insulating sheathing board on the skew faces. This practice was developed for use on silica roofs. In basic construction, about 1 per cent of the total arc of the roof is made up of such insulating board spacers divided evenly on the two skew faces.

In service, the insulating board is destroyed near the hot face, but it merely chars and compresses to some extent near the cold face. Thus, it provides for greater expansion of the hot face while supporting the cold face.

Recently, this type of expansion allowance has been supplemented with about 0.75 per cent of the total arc of the roof as thin asbestos spacers inserted in every other hot face joint to a depth of only about 2 in. This provides hot face expansion but none for the cold face. This arrangement of expansion allowance is illustrated in Figure 8.

The combination of the insulating board on the skew faces and the asbestos strips in the hot face joints has been eminently satisfactory. On heating such a roof, even though the skews are free to move, little or no movement is observed.

Spring supported skewback—Design provision for roof growth across the arch resulting from plate oxidation in the joints is achieved by suspending the rear skew of the arch and supporting it laterally by a spring arrangement. The spring support is used so that the pressure applied across the roof can be controlled within predetermined limits. No special expansion provision is necessary for longitudinal roof growth but greater expansion allowance is provided.

The spring support for the skews also provides another reason in favor of full suspension of the roof. With full suspension, very low skew pressures are possible. This tends to insure that little force can be applied to

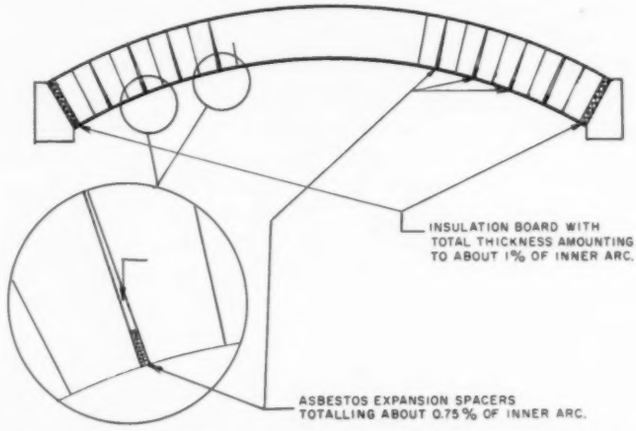

INSULATION BOARD WITH TOTAL THICKNESS AMOUNTING TO ABOUT 1% OF INNER ARC.
ASBESTOS EXPANSION SPACERS TOTALLING ABOUT 0.75 % OF INNER ARC.

Figure 8 — Expansion provision has combination of insulation board on the skew faces and asbestos expansion spacers in joints at the hot faces.

the brick hot face. If only partial suspension is used, skew pressures must be much greater. Where this practice is used (66), elaborate and difficult procedures of spring adjustment have been used to maintain the roof in its original position and keep it from rising. If much rise of the roof were permitted, the roof thrust would be exerted on the hot face and refractory failure might result. The use of full suspension and light springs on the rear skew virtually precludes this possibility.

Roof growth of as much as 8 to 10 in. at the skewback, has been observed. However, the movement this growth causes does not appear to be as harmful to the roof as other movements. The probable reason for this is that the plates "grow" deep in the joints away from the hot face. However, if the growth is not accommodated, it can cause the roof to buckle upward. When this occurs, the thrust of the buckled area must be carried on the hot face. Rapid wear in such areas has been observed.

The spring supported, suspended rear skewback provides the best means for accommodating roof growth that has been devised to date. However, a basic roof in service becomes so welded together that it acts like a

monolith. In this condition, local buckles can occur which the springs will not accommodate.

Ribbed roofs—Most fully suspended basic roofs have been of uniform thickness, although the rib and valley construction is now being tried. The use of the rib and valley construction tends to provide a more stable structure. It should tend to counteract the buckling action which may occur. Another advantage of the rib and valley roof is that when patching becomes necessary, the patch can be stopped adjacent to a rib with adequate lateral support even though the roof thickness in the next valley would not be sufficient for this purpose. With a uniform thickness roof, a much larger patch would be required.

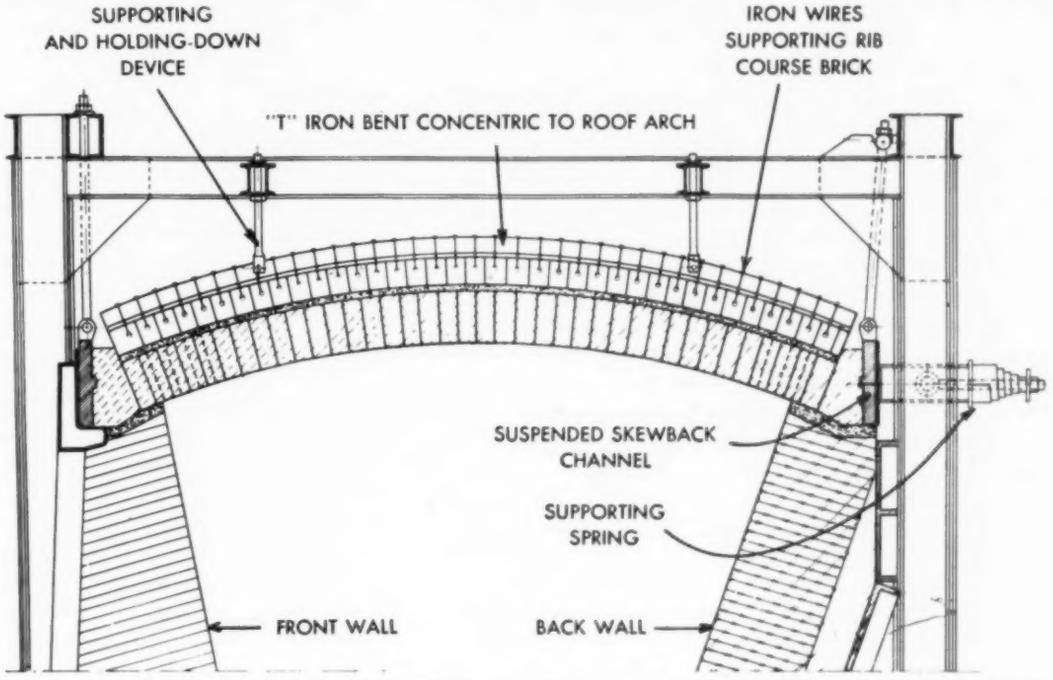


Figure 9 — General arrangement of suspended arch on a European all-basic furnace.

BASIC ROOF CONSTRUCTIONS

Partially suspended ribbed roofs—The European roof design used almost universally, to date, has been essentially a rib and valley, true arched roof, which is only partially suspended (4, 40, 45, 49, 63). The rib courses are suspended but the valley courses are sprung. The rib courses are held down as well as suspended, to help maintain roof shape. Schematic diagrams of this arrangement are shown in Figures 9 and 10.

The rear skewback of the roof is suspended and supported laterally by springs. The skew is also free to pivot around a horizontal axis to provide additional differential expansion allowance for the hot and cold faces of the roof. Otherwise, the only expansion allowance across the roof is made with wire gauze in the radial joints. Longitudinal expansion is provided as small block-type joints at intervals along the length of the furnace.

Such roofs are laid on centers and the brick are attached to the suspending members after bricklaying is finished. This design meets the requirements of good basic construction. The combination of partial suspension and sprung construction necessitates extremely careful control of skewback springs during heating up and operation of the furnace. Improved design of transverse expansion allowance would probably ease this situation.

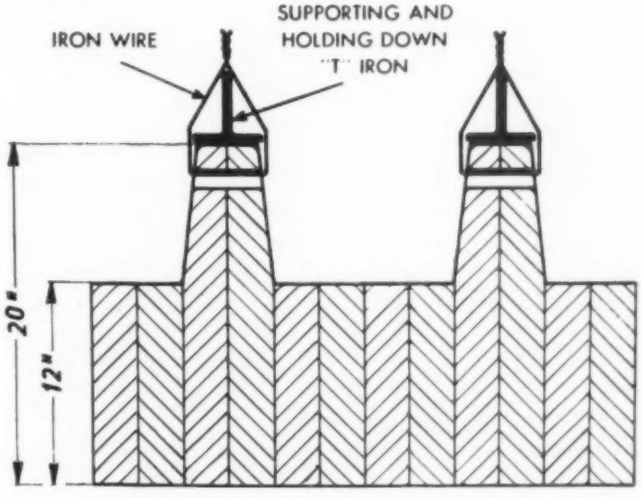
The holding down devices used in conjunction with the suspension do not appear necessary on the basis of American trials with fully suspended roofs. However, they may be helpful to the partial sprung construction.

Trials of fully suspended constructions, according to American practices, are now progressing in Europe.

Fully suspended corbelled roofs—The earliest suspended basic roofs in America consisted of vertically hung brick forming a flat roof with a small corbelled construction along the skewbacks (4, 64). Figure 11 shows a schematic diagram of this arrangement.

The skewbacks with this arrangement may be rigid or suspended. However, when suspended, no spring support is provided. Instead, a compressible insulating block may be inserted between the skewback channel and the furnace buckstays, to provide a yielding support. Expansion is usually provided as ½-in. wide block joints on about 2-ft centers.

Figure 10 — Longitudinal section of a European all-basic roof.



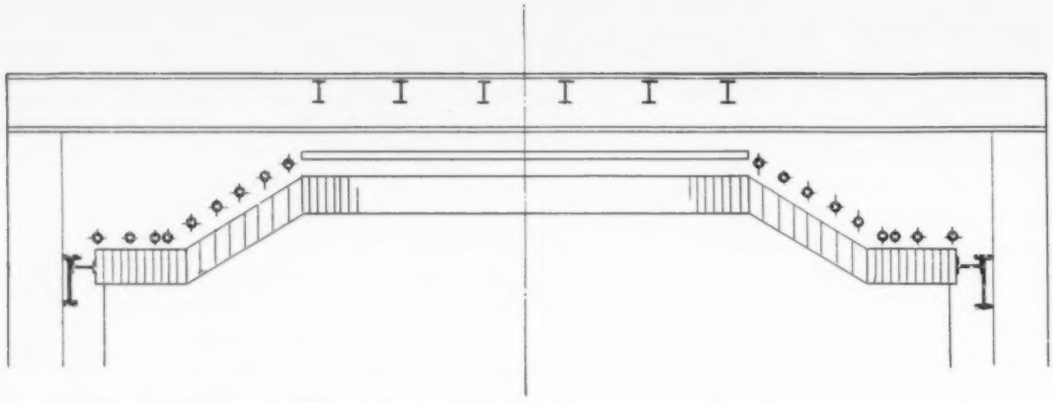


Figure 11 — This brick arrangement was used in first American all-basic roof.

The roof is hung from the steel superstructure by bricklayers standing on scaffolds built in the furnace.

Despite the disadvantages of the corbelled arrangement, the block expansion joints and the absence of spring support on the skewback, this style of construction has continued in use in both the copper industry and on some open hearth port roofs. Recently, a European furnace was built with double internal plated brick using a similar construction and has operated with apparent success. However, in almost every case where construction of this type is used, it is probable that improved results could be achieved by changing the construction to more modern designs.

Suspended radial roof—A true radial arch design for basic furnaces developed in America is shown schematically in Figure 12 (65). In this arrangement, suspending members are bent or cut to be concentric with the desired arch contour. Key-shaped brick, suspended by hangers from these members, are laid against skewbacks to form the arch.

The rear skewback is suspended and supported laterally by light springs. In early trials, block expansion joints were used, but later the combination of 1 per cent insulating board on the skew face and 0.75 per cent of asbestos spacers in the hot face joints, has been adopted for transverse expansion. Longitudinal expansion of about 2 to 3 per cent has been provided using block-type joints of about ¼ to ⅜ in. every 12 to 14 in. along the furnace.

In most cases, such roofs have been hung from the steel superstructure by bricklayers standing on scaffolds in the furnace. However, using brick with tab hanger accommodation, the brick can be laid on centers and attached to the steelwork later.

The radial roof provides all the requirements of good construction. It has been used for over two-thirds of the suspended basic open hearth roofs used in America and is used on two of the existing basic furnaces. This style of roof is also being used on recent copper furnace installations and is being tried on European open hearths.

It is interesting to note that during the period of operation at one of the existing all-basic furnaces, the rise of the roof has been changed from time to time so that

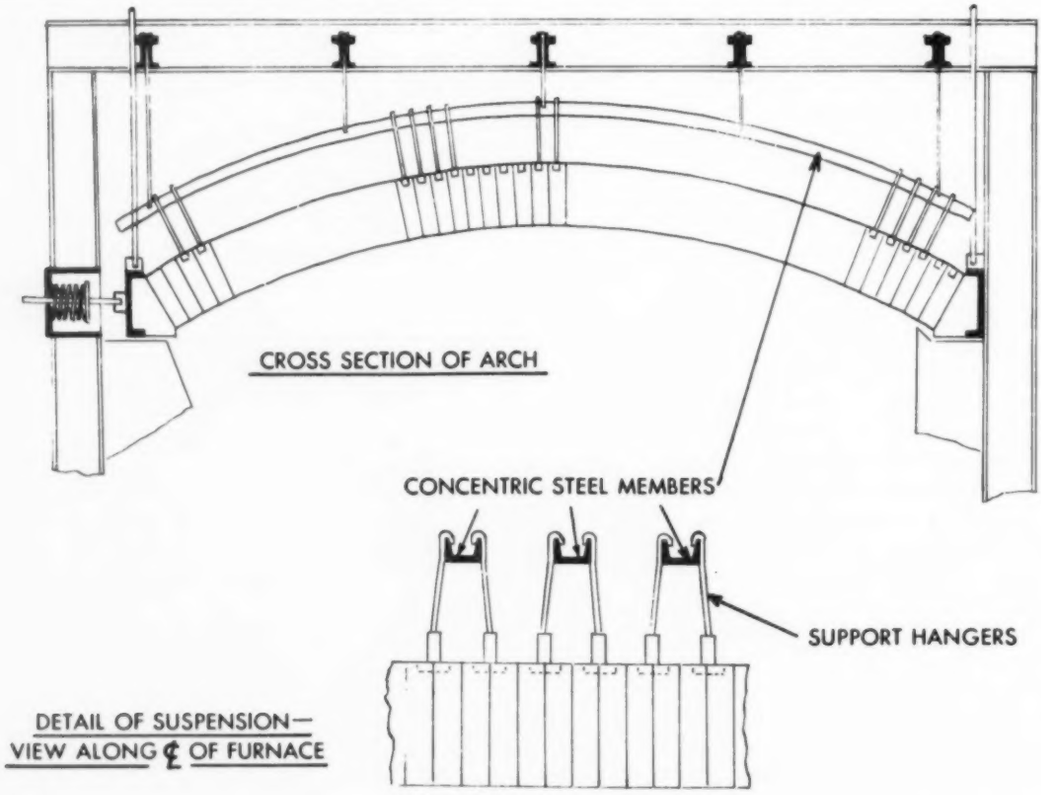


Figure 12 — General arrangement of an American radially suspended arch.

a range from approximately one-half inch per foot of span to about 1.6 inches per foot of span has been covered. No outstanding difference in performance as a result of these changes has been noted. In view of this, it might be expected that no great difference would occur if an entirely flat roof were used. This appears to be the case.

Flat suspended roofs—The flat suspended basic roof is now being tried for the open hearth. This design returns to the vertically hung brick arrangement, the roof being flat from front to back and from end to end. In this way there are no corbels in the roof. This arrangement is shown schematically in Figure 13.

The spring support at the rear of the flat roof has been retained in this design development. The expansion provision has normally been of the block type with ½-in. wide joints on about 2 ft centers. Roofs of this design are hung from the steel superstructure by bricklayers standing on scaffolds built in the furnace.

It had been hoped that the flat roof would eliminate buckling of the roof. However, buckling of flat roofs has occurred. Buckling of the roof appears to be more a function of roof growth as a result of plate oxidation rather than one of roof shape.

With flat roofs, the front and back walls must become quite high so that the roof is not in danger of being hit by scrap during charging. Normally, it is

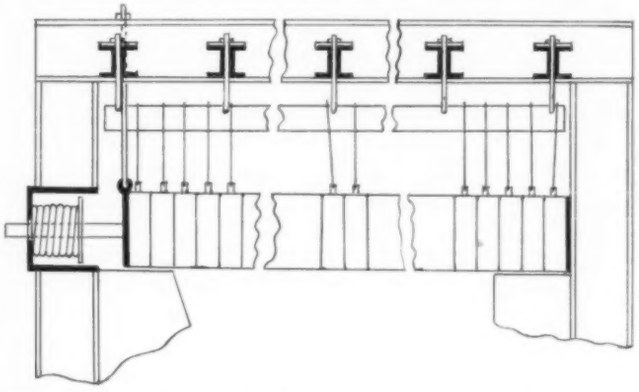


Figure 13 — Schematic diagram shows general arrangement of a flat basic roof.

necessary to suspend the upper portion of the front wall, particularly in those areas that form the door lintels. Also, it has been deemed advisable to install water coolers in the upper sections of the back wall.

Completely sprung roofs—Still another possibility for all-basic roof construction is the completely sprung roof (61). Several such sprung arch constructions with rigid skewbacks have been tried on open hearth port roofs and main roof sections of less than 16-ft span (66). They have been quite successful, though their use is still in the development stage. Virtually the only difference between these sprung basic roof sections, some of which have lasted in service for more than 700 heats, and those which failed miserably in early basic roof experiments both here and abroad, is in the expansion provision. In view of this, it follows that sprung arches of larger span may be feasible. This is probably true. However, to construct large sprung basic arches, it is probably necessary to strengthen the furnace frame considerably to carry the additional weight of the basic brick. The cost of such work would approach that of the changes needed for suspended construction. Further work must be done to determine the extent to which sprung basic arches can be used.

THE OPERATION OF ALL-BASIC OPEN HEARTH FURNACES

The field of furnace operations is one in which many changes have occurred since the beginning of all-basic furnace trials. These changes have had broad effect on the success of the all-basic furnace, more effect, in fact, than the improvements made in the fields of refractories and furnace construction.

Increased furnace productivity has been the order of the day. For example, in the decade from 1946 through 1955, yearly production climbed from 81,200,000 tons to 110,200,000 tons. During the same period the number of operating open hearth furnaces actually decreased from 990 to 924 (67). The increase in productivity for the average individual furnace was over 45 per cent.

The principal function of an open hearth furnace is to supply the heat necessary to melt and finish the charge (68–72, incl.). In view of this, the increase in productivity represents a tremendous increase in the heat released within furnace walls. It also represents substantial increase in the effective furnace temperature.

Open hearth operations are conducted at temperatures approaching that of the melting point of pure silica. With any major increase, the furnace temperature is liable to exceed this value. If this is done, the wearing rate of silica refractories becomes disastrous. The need for more refractoriness in the furnace structure becomes imperative. The all-basic furnace meets this requirement.

This does not mean that improvements of productivity of silica furnaces have not been made or are no longer possible. To the contrary, almost all of the progress made thus far has been accomplished in silica furnaces. Further improvements can still be made. However, in almost every instance, the limiting factor on further increased productivity is the refractoriness of silica in the furnace or fireclay in the regenerators. With basic materials in these sections, the efficacy of the same practices which promote production but destroy acid refractories, is enhanced and still more production can be obtained with the use of all-basic construction.

To demonstrate this, a review of the major practice changes used in achieving higher productivity and their impact upon the all-basic furnace is in order. Evaluation of these factors in this relationship will also indicate where further improvements are likely to be found.

The changes in practice which yield greater production can be classified broadly into four groups, namely, those dealing with the furnace charge and its distribution, with combustion, with metallurgical refining, and with furnace availability.

Improvements of productivity related to furnace charge—Practice improvements for increased productivity with regard to furnace charge and its distribution include increases of heat size (73–75, incl.), faster charging of the furnace with scrap preparation and improved handling (76–84 incl.) and increases of the hearth area of the furnace (85–89, incl.).

Experience to date shows that when heat size is increased, the larger cold charge becomes a more efficient

heat absorber. In effect, the temperature difference or heat head between the hot furnace and the cold charge is increased, thus promoting heat transfer while heat losses from the furnace remain relatively unchanged. Heat time may increase but productivity per hour also increases.

Normally, heat is supplied at a faster rate with the larger heats and refractory wear increases. In many cases, this increase of refractory wear has been sufficiently severe that necessary repairs seriously affect furnace availability. As a result, with furnaces of increased heat size, there has been an increasing trend toward the use of more and more basic refractories. For example, almost all furnaces over 250-ton capacity are equipped with fully basic ends. Little operating experience with all-basic construction for furnaces of largest size has yet been obtained, although such installations are now being tried. Everything points to a successful application.

With large size furnaces, a huge volume of scrap is charged. With its great heat absorbing capacity, there is a tendency toward greater temperature fluctuation. As has been pointed out, wide temperature fluctuation with corresponding thermal expansion and contraction, encourages wear of basic roofs. These temperature swings can be minimized by firing high fuel input rate during the fettling and charging periods. This should be done.

With internally plated brick, wear from this cause is no longer considered a critical factor. For example, recently such brick in a top charge electric furnace of about 135 tons capacity have withstood the drastic heating and cooling required in making three- to four-hour heats. Such severe treatment is not likely in any open hearth.

All-basic furnaces are well able to withstand the conditions found in furnaces of increased size such as those making double size heats for tapping through bifurcated spouts. No concession on improved productivity from the use of increased heat size is required for the all-basic furnace.

Rapid charging of the furnace decreases heat loss. The undesirable heat loss can be countered to some extent and furnace temperature maintained even better by the maintenance of high firing rate throughout the charging period. These factors have tremendous effect in promoting fast melting. Improvement of scrap preparation and handling, increases of charging box size, etc., to speed charging, materially increase furnace production.

The effect of the more uniform roof temperature provided by rapid charging is beneficial to basic refractory life. It has little effect on silica life. For basic furnaces, rapid charging is highly desirable both for this reason, as well as for its production advantages.

Increasing of the furnace hearth area to provide a greater exposed area of charge for heat transfer has, in itself, little or no effect on basic refractories. However, without basic refractories, increases in hearth area of the magnitude which have been achieved, would not have been possible. The use of basic refractories in furnace ends with thinner walls, suspended construction and the design changes permitted by their greater refractoriness, has made available considerable space formerly required for structural stability of the furnace end. This can now be utilized to provide additional melting space.

Increases of furnace productivity of as much as 8 per cent have been reported as the result of substantial increases of hearth area (89). However, such increases are closely related to combustion practice and port design. These can also affect productivity and it is difficult to separate the effects of each. These subjects are discussed later.

Upon review of the size of the ends of most furnaces, it appears that full advantage of possible increases in hearth area have not been realized. Further development along this line entails the use of fully basic ends and re-design of furnace ports. Greatest improvement can be realized if the heat head above the heat transfer surface is materially increased. This requires that basic roofs be used.

Overall, the all-basic furnace is well suited for the adoption of the various practices related to furnace charge which tend to promote production. In one instance, the attainment of maximum hearth area within a limited space, the use of basic refractories is essential.

Improvement of productivity related to combustion—The importance of achieving the maximum obtainable heat head in the furnace chamber above the bath has long been recognized as a major factor in rapid melting operations (39, 68, 69, 70, 71, 72, 90, 91). A greater heat head can be achieved by bringing more fuel into the furnace system or by providing conditions which promote more efficient combustion, or both. In either event the temperature of the furnace, throughout its parts, is increased. Frequently the volume of gases which must be handled by the furnace is also increased. Both of these factors contribute materially to the wear of refractories.

Inasmuch as the rate of wear of silica and fireclay refractories has been the limiting factor in determining the temperature at which the furnace can be operated without excessive maintenance, the advantage of more refractory materials which will withstand higher temperatures is obvious. Basic refractories provide this condition. The use of the all-basic furnace permits the use of operating practices which increase furnace productivity but destroy acid refractories.

Increase of fuel input—Fuel input into the furnace can be increased in two ways, by increasing the maximum input rate or by maintaining high input rate for a longer time. Generally, where basic furnaces have been operated, they have had a greater fuel input from both sources than corresponding silica furnaces (92). This has been true despite notable increase in the firing rate of the silica furnaces. For example, in one shop the average fuel consumption per hour for silica furnaces increased about 15 per cent from 1950 to 1955, while the basic furnace average was maintained at about 16 to 25 per cent above the silica firing rate. Other basic furnaces have operated at 10 to 25 per cent greater fuel input than corresponding silica furnaces.

With the increase in fuel input into silica furnaces, silica roof life has dropped markedly despite improvement of the silica refractories and other ameliorating changes. Under similar conditions, basic roof life has increased with improved brick and improved construction.

In some cases, the basic furnaces have operated at

about the same maximum input rate as the silica furnaces, but the maximum firing rate has been continued through the ore and lime boil periods when normally the fuel input would be reduced with silica roofs to prevent "burning" or rapid wear. During these periods with the bath actively boiling or "open," it is in condition to absorb heat rapidly, but because of the reflecting nature of the bath, silica refractories cannot stand up without decrease of fuel input. With basic roofs the rapid heat transfer provided by maximum firing rate can proceed.

The higher firing rates with all-basic furnaces have produced melting rates varying from about 10 to 25 per cent over corresponding silica furnaces. The variation is caused by the many other factors which affect productivity. Where maximum firing rate has not been increased, the increase in productivity has been in the neighborhood of 10 per cent. These comparisons are true even though the productivity of silica furnaces has been increased by as much as 25 per cent during the period of comparison.

Combustion conditions—In all the foregoing it is assumed that the increased fuel input has been burned efficiently to achieve good heat transfer. The results indicate that this assumption is true (39, 81, 82, 85, 93, 94, 95). However, efficient burning of more fuel is not always easy. Five years ago fuel input of 100,000,000 Btu per hour was regarded as high. Recently 200,000,000 Btu per hour has been mentioned as being within practical limits (61). To burn such large volumes of fuel within the confines of an open hearth furnace chamber requires that the fuel and necessary combustion oxygen be mixed intimately and quickly, achieving a high flame temperature and/or a more radiant flame.

This can be done by improved regulation of fuel and air sources, atomizing media, furnace pressures, draft and other normal combustion controls (85, 94, 96); by the use of oxygen enriched air for combustion (97–105 incl.); by the adoption of furnace chamber and port designs which favor rapid combustion or by a combination of these factors (85, 89, 106–112 incl.).

A tremendous amount of work has been done on the first two of these factors with outstanding increase in furnace productivity. Aside from the fact that these factors universally increase furnace temperature and thus eventually require the more refractory basic materials, they have little other effect on the all-basic furnace or vice versa. However, with regard to the possibilities of improvement of furnace and port designs for better combustion and heat transfer, the use of basic refractories and the all-basic furnace have greater impact.

Furnace contours—In America, almost all design principles regarding furnace contour have been based on the use of silica refractories in the open hearth roof and wall structure. This imposes many limits and frequently prescribes designs that are disadvantageous.

As basic brick have increased in use, first in front and back walls, then in end walls and fully basic ends, and finally in the main roof, their advantages in greater refractoriness, in the ability to withstand high velocity gas streams running parallel to their exposed face, and their long life in relatively thin walls, have permitted many design changes which were helpful to combustion and furnace productivity.

Coincidental with the accumulation of this practical experience, research on the character of flames (90) and on gas flow patterns throughout the furnace system (109) have indicated the desirability of many design changes which are possible only through the extended use of basic refractories. The ineffectiveness of large burner blocks, monkey walls, roof knuckles, port roofs sloping downward from the end wall, and overly large air uptakes in promoting good combustion, are only some of the factors which have been determined.

Uptake design—The relationship of the use of basic refractories on uptake size is particularly revealing. When basic brick were first used in end structures, the interior furnace lines were maintained almost exactly in the contours required by silica, although walls were much thinner. Then, with the suspension used, it was possible to increase the flue area of the end by as much as 50 per cent. In most cases this was done with the thought that refractory wear would be decreased. Instead, wear of the end walls was increased and furnace productivity fell off. When the original lines were rebuilt, the furnace productivity came back. Trials of smaller uptakes almost invariably improved furnace productivity provided the furnace system had sufficient draft capacity, etc., to handle the greater obstruction to gas flow (4, 89, 110, 111).

With this experience and observation of the small uptakes commonly used in European (basic port) furnaces, a trend toward smaller uptakes and furnace ends started. It is still progressing. Whereas prior to about 1950 it was thought necessary to provide about one sq ft of uptake area for each 1,000,000 Btu fired at maximum firing rate, now many furnaces have uptakes which provide only 0.5 sq ft per 1,000,000 Btu. Silica brick do not stand up satisfactorily in such ports.

The improvement of combustion and resultant productivity with small uptakes is related to an increase in incoming air velocity which, if properly directed promotes better mixing of the air with the fuel.

Single uptakes of the same size as previously used for double uptakes usually have not worked as well from a combustion standpoint, although when this has been done in conjunction with increases of hearth area mentioned earlier, the combined effect on productivity has sometimes been beneficial.

Probably the ultimate result of the present trend towards smaller uptakes is represented by the Maerz design for port ends, now widely used in Europe. This design is based on the use of a relatively high velocity incoming air stream developed by unusually small uptakes, both to mix the air with fuel and to position the flame in the furnace. Such ports provide only about 0.3 sq ft of uptake area per 1,000,000 Btu maximum firing rate.

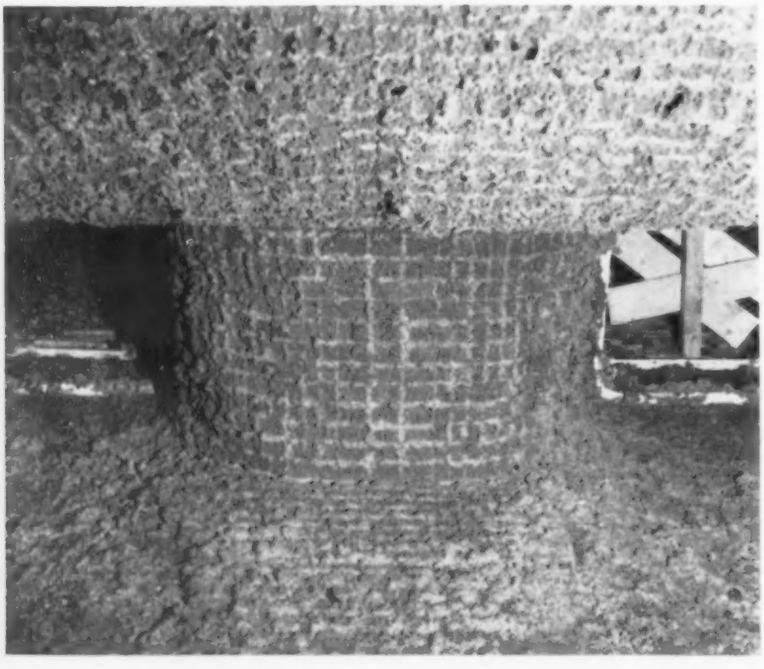
It is interesting to note that Maerz designs for both single and double uptakes are offered. However, with single uptakes, the furnace chamber is drastically necked in as it approaches the port at the "knuckle" position. Because of this, the single uptake design is characterized by much greater wear of refractories in the port section than is the case with the double uptake design. The double uptake appears to be preferable for this reason.

One such furnace with basic roof and ends has been built and is operating in this country. It is a 175-ton furnace. The uptake area for one end is only 22 sq ft. Figure 14 shows the size of one of the uptakes in this furnace. Figures 15, 16, 17 and 18 show the interior of

Figure 14 — Maerz end uptake is under construction.

Figure 15 — View is taken looking up a Maerz end as constructed.

Figure 16 — View is taken looking up a Maerz end after 249 heats.

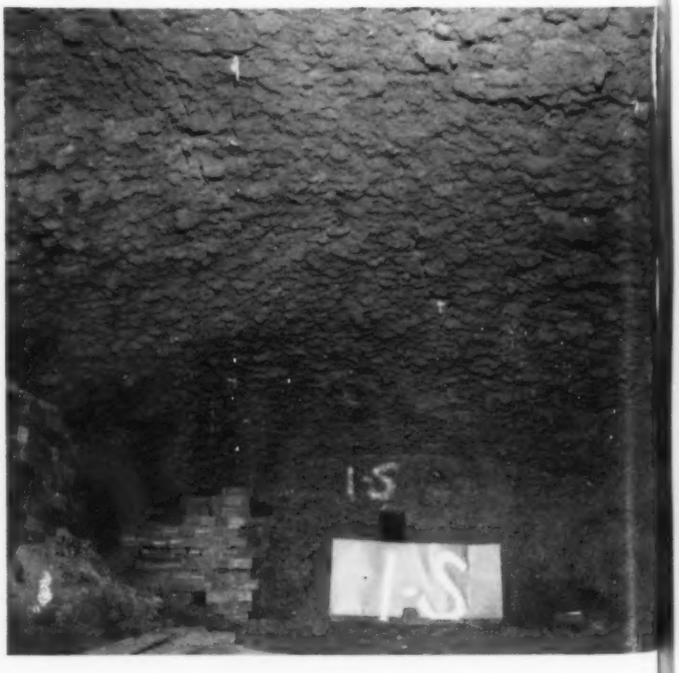


this furnace as constructed and after 249 heats. At the time the pictures after use were taken, the furnace was down for vacations. The results obtained, though not complete, appear very good. In comparison with another all-basic furnace in the same shop, which has a single uptake of about one-third larger area, the Maerz furnace is about equal in fuel rate and in productivity, despite a much poorer regenerative system. Wear of the refractories in the Maerz ends has been extremely low, particularly in the uptake regions. Few repairs of the ends have been made in over 400 heats, whereas the other basic furnace had end wall patches before 200 heats, and replacement shortly thereafter.

Convergent front and back walls—A convergent wall furnace has recently been developed in Europe as the Maerz-Boelens furnace (113). Our conventional outwardly-sloping front and back walls permit easy main-

Figure 17 — Interior of an American Maerz furnace as built.

Figure 18 — Interior of an American Maerz furnace after 249 heats.



tenance and long life of these units, but they necessitate a much larger roof. The larger the span of either silica or basic roofs, the shorter the life. Thus, the effect of normally sloping back walls or front walls is to shorten roof life.

Basic refractories have now been improved to an extent, for wall construction, that the sloping arrangement is no longer needed. Suspended basic construction has been so improved that it is possible to construct the front and back wall so that they converge toward each other, as shown in Figure 19. The roof span can thus be cut by as much as 40 per cent and roof life materially increased.

This construction was tried in a small 35-metric ton furnace in Belgium. Reports of this operation show

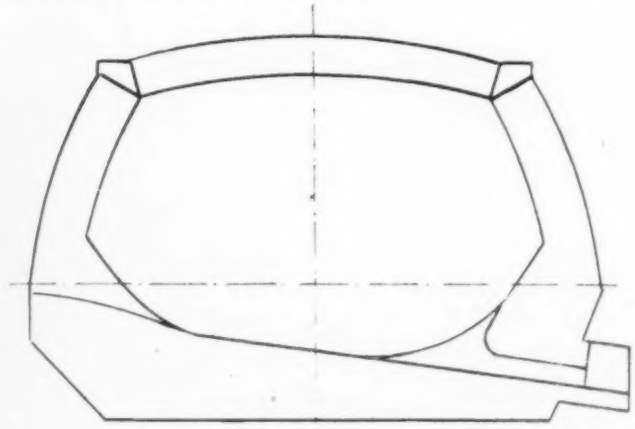


Figure 19 — Furnace profile has converging front and back walls.

longer length of furnace campaign; greatly decreased refractories usage, both for original construction and repairs; notably reduced fuel consumption per ton; and increased furnace productivity.

Figure 20 shows the comparison of the flame distribution around the charge in the furnace chambers of the old and new shapes. With the new profile, the flame is brought closer to the charge, and heat transfer by both convection and radiation is materially increased. Similarly, the radiation heating from the furnace walls to the bath can only be improved by the new profile. At the same time, the external area of the furnace which radiates heat lost to the atmosphere has been materially reduced, with corresponding heat saving.

Actual results of operations with the new profile showed lower fuel consumption per ton and increased melting rate, even though fuel input rate per hour was actually decreased. This can happen only with more efficient heat transfer.

In addition to these combustion effects of the new profile, it is believed that the almost oval arrangement of the furnace cross section decreases recirculation of waste gases into the flame. Such recirculation of waste gases can drastically reduce flame temperatures.

Six Maerz-Boelens furnaces are now operating in Europe. Figure 21 shows a schematic diagram of a furnace of about 150-ton capacity in Germany. Note the suspension provided for the front and back wall and the suspended arrangement forming the door lintels. This area can be repaired from outside the furnace. The roof is arranged in segments or bungs which can be applied to the furnace by a crane. The brick are all steel-clad, with the hangers engaging steel clips pressed into the cold end of the brick, as shown in the center of Figure 5. Figure 22 shows the front view of this furnace as built.

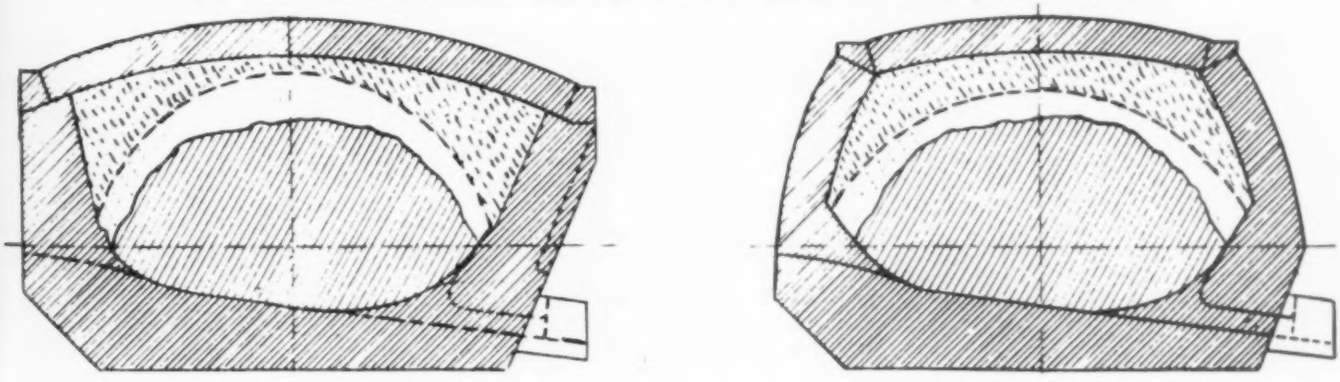
Reports of the operation of this furnace show a maximum production rate of over 22.0 tons per hour tap-to-tap, and a fuel consumption of about 4,000,000 Btu per ton with a charge of approximately 30 per cent hot metal. By comparison with other similar operations, this record is very good. It seems likely that investigation of such changes of design are warranted in this country.

The success of these developments, the trend toward smaller uptakes, and the changing of furnace cross-section, both of which are at least partially dependent upon basic refractories, suggests that other similar design changes might be extremely worth while. Design thinking should be predicated on the attributes of basic refractories, not the limitations of silica. It seems probable that improvement of furnace design on the basis of the capabilities of all-basic furnace constructions presents greater possibilities for increased productivity than most other fields of study.

Air preheat temperature—Still another means of getting a greater heat head in the furnace chamber is through the use of air preheated to higher temperature. The importance of high air preheat in promoting furnace productivity has been catalogued by numerous investigators. In average, for each 100 F increase in air preheat, heat time has been decreased 45 minutes to one hour (39, 60, 61, 72, 85, 91, 114–121, incl.).

The importance of high air preheat cannot be overemphasized. To achieve the ultimate productivity with an all-basic furnace, it is necessary to take advantage of this factor to the utmost.

Figure 20 — Comparison shows flame distribution in furnace chambers of different profile.



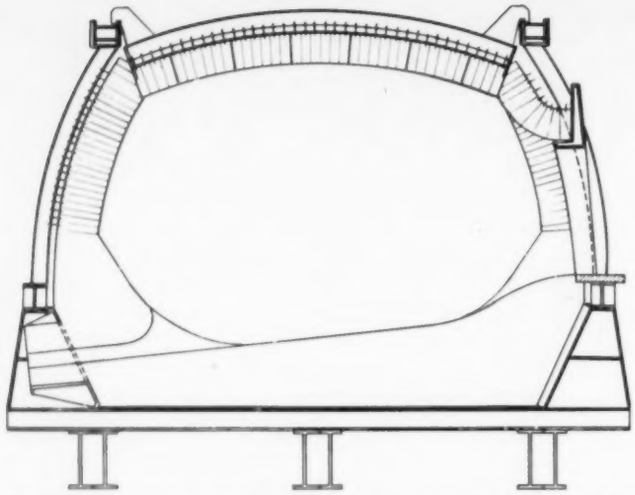


Figure 21 — Schematic diagram of new furnace profile construction.

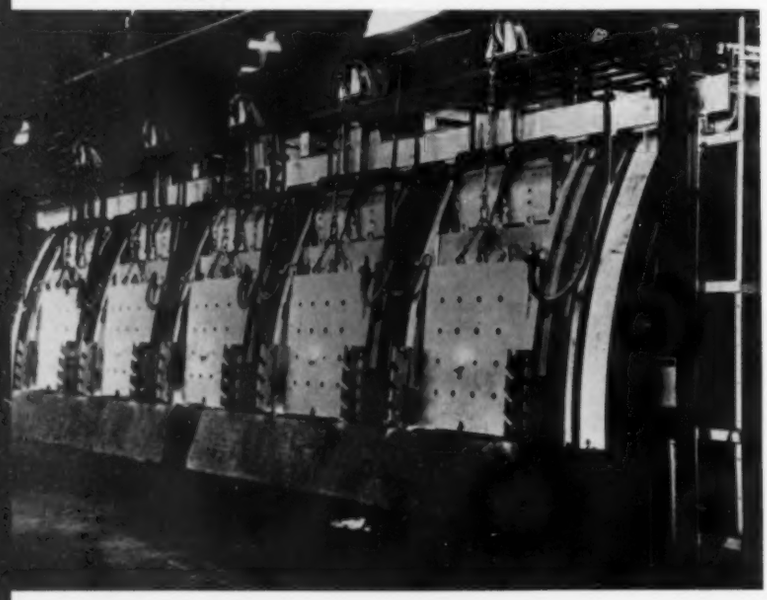
There are two major items which affect the degree of air preheat, the amount of air infiltration and the amount of temperature and the temperature distribution of regenerative surfaces. Both of these affect, or are affected, by the use of basic brick.

Air infiltration can act as a diluent and coolant for preheated air on the incoming end of the furnace, or as a cooling agent for the regenerator on the exhaust end. Either effect is equally damaging to the development of air preheat.

Because of the expansion of basic walls as a result of plate oxidation in the joints, there has been a tendency to provide large expansion allowance in basic end construction. This undoubtedly has promoted additional air infiltration over silica construction, and has had adverse effects upon fuel consumption. Later constructions, in which expansion allowance was decreased, provided tight ends with low infiltration.

This fact helps to explain why early basic furnaces showed fuel disadvantages despite higher productivity. Later comparisons in which all-basic furnaces were compared with silica roofed furnaces equipped with basic ends, have shown fuel saving, as might be expected.

Figure 22 — View of front of 150-ton Maerz-Boelens furnace.



Extreme care in the construction of basic ends is necessary to cut air infiltration to a minimum. If too little expansion allowance is provided, structural difficulties and premature failure can result. Conversely, if too great expansion provision is made, excessive air infiltration, with its drastic effect on productivity can occur.

Grouting and insulation of suspended sections of basic ends were little used on early installations. More recently, grouting of the outside of the wall with fine-grained basic material sprayed in place, is recommended and the use of thin coats (less than 1 in.) of plastic insulation, is acceptable. Both of these practices tend to decrease infiltration.

Regenerator design—The amount, mean temperature and temperature distribution of the regenerative surfaces of a furnace have an equally important effect on air preheat. In this connection, regenerative surface includes all the surface area of the furnace ends, fantails, etc., to which the incoming air is exposed prior to being delivered at the top of the uptakes (39).

Insufficient checker capacity has long been recognized as a cause of low preheat. More recently, an insufficiency of high temperature regenerative surfaces have been shown to be a cause of low preheat. This latter factor has also shown up in basic end construction where the surface area of basic walls in the ends is much smaller than in corresponding silica ends. Reasons for this smaller surface area in the ends are the absence of the large arch at fantail elevation with a burner support above it, and, in some cases, the smaller end structure itself. This, with possible greater infiltration, probably explains the sometimes unsatisfactory fuel figures of some basic end installations.

To counteract this effect it is necessary to obtain more high temperature regenerative surface in the furnace system. In most cases this is not possible without changing the checker chamber arrangements. However, there is a feasible solution. Again it entails the use of basic refractories.

The normally used fireclay checker brick will not stand higher temperatures than are now prevalent in most checker chambers. In some cases doors have been opened in the exhaust end, slag pocket seals or water sprays have been introduced into the exhaust end slag pocket to cool exhaust gases below the temperatures which cause excessive wear of the fireclay checkers. Such practice, while it undoubtedly prolongs checker life, can only be deplored from a heat and fuel consumption standpoint.

Replacement of the fireclay brick with more refractory materials helps this situation. However, the apparently logical step of substitution of higher alumina content materials usually does not suffice unless the alumina content of the checker brick material is raised to something over 75 per cent. The reason for this is that, at lower alumina content, the materials are merely alumina grains bonded with fire clays. As such, they exhibit most of the characteristics of fluxing, build-up and plugging of the checker setting that fire clay itself does. Higher alumina materials cost more than basic brick and do not have the unique advantages of the basic refractory. Therefore, the truly logical step is directly from fireclay to basic checkers.

Basic checkers—The basic brick show little reaction

with the high iron oxide content dusts normal to open hearth checkers. While they may build up some deposit on their horizontal surfaces, their sides stay clean and the holes through the checker setting stay open. Horizontal surfaces in the setting can be minimized by the use of chimney flues throughout the checker. The material that collects on the top can normally be blown off readily. The solid flue setting also provides the support and stability required by the basic material.

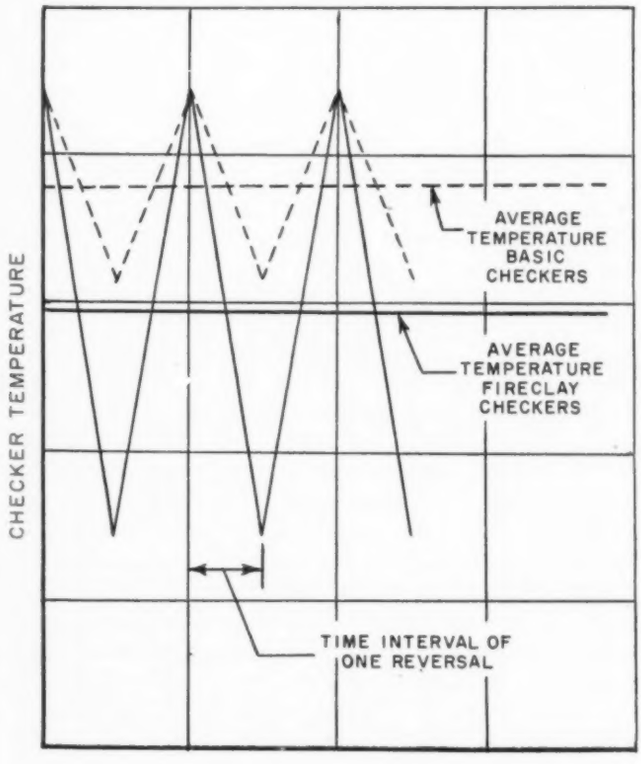
Basic checkers have been tried in a number of furnaces in this country and have been used more widely abroad. Reports of their service life appear to indicate that they pay for themselves on a straight replacement basis, outlasting the fireclay checkers by several times.

Some advantage has also been claimed for additional preheat from the basic checkers (122). The basic checkers are almost twice as heavy as fireclay and have much greater heat capacity. This would tend to raise the average temperature of the chamber (and the preheat) if the maximum checker temperature is kept at the same point and the reversal periods are the same. This is shown diagrammatically in Figure 23. European investigators have noted the smaller temperature swing of the checkers with reversals when basic checkers are used.

The basic materials also have higher heat conductivity than fireclay. However, this property is probably of relative unimportance as has been pointed out by several investigators (123).

The properties of basic checkers suggest that design changes of the checker chamber could be made with greater advantage than that previously achieved by merely substituting basic for fireclay in a given design. In many cases, fireclay checker settings are designed relatively open to avoid the plugging of the fireclay material. In others, the settings are made with relatively thick brick because the fireclay melts away. With basic materials, neither of these procedures is necessary.

Figure 23 — Checker temperatures are given for basic and fireclay checkers assuming maximum temperature and reversal time are constant.



A checker setting for basic materials using relatively thin brick, for example 2 in., and with holes of smaller size would be a much more efficient heat exchanger than most normal fireclay settings. The greater weight of the basic material would provide more capacity for heat storage. The smaller size holes would provide more heat exchange surface and would require the gases to travel through the setting at greater velocity, thus wiping the surfaces better and exchanging more heat. The sum total of these effects has yet to be determined, but it is known that the overall effect would be great. When fireclay settings have been built with small holes, preheating of air is good and furnace operation sharp until the checkers plug.

Two-stage regenerators—The mere use of small openings does not provide all the possible advantages from basic checkers. In many cases it is not possible to raise the checker temperature materially because the checker chamber is too large.

For example, if a bunsen burner were pointed in the doorway of a room, the temperature of the room is barely changed. However, if the same burner is inserted in an opening in a four inch cube, the temperature of the enclosure would rise considerably. An open hearth checker chamber follows the same pattern.

High temperature heat comes from the furnace through a relatively small port of not too great heat capacity (if it is a basic end), and is discharged into a relatively large cold checker chamber. The temperature drops sharply and only after a long time of gas flow will the temperature of the chamber climb to any point approaching that of the incoming gas. The larger the chamber, the lower the temperature and the longer the period required for heating.

In view of this it appears that in many cases, even with furnaces that are supposed to have less than adequate checker capacity, benefit could be derived from actual decrease of size of the primary checker so that it would operate at a higher temperature. This would require basic checkers. The basic checker would be followed by an independent fireclay regenerator.

A furnace designed around this principle is being operated in Europe. It taps 150-ton heats with a tap-to-tap production rate of 18.0 tons per hour on a 27 per cent hot metal charge. The fuel consumption is only about 3,300,000 Btu per ton. This result is very good even though the amount of stack checkers used is considered inadequate.

The field of checker design is another area where, through improvement on the basis of the attributes of basic checkers, major improvement of combustion with resultant increased furnace productivity and fuel saving is capable of attainment.

Improvement of productivity related to metallurgical refining—There are numerous procedures for accelerating steel refining in the open hearth furnace. Probably the most effective of these is the blowing of oxygen into the bath to speed melting and/or decarburization (79, 92, 97, 98, 99, 102, 103, 104, 113, 124–130, incl.). Use of oxygen for this purpose has grown tremendously during the last decade. It has become standard practice in many plants. However, in many instances, more oxygen could and would be used were it not for the adverse ef-

fect of the practice on the life of silica refractories. The use of the all-basic furnace tends to minimize this effect.

Oxygen blowing into the bath, by lances through the doors, by jets through the roof, or by other means, creates violent bath reaction. The oxygen diffuses through the bath rapidly and reacts with carbon to form gas which causes wild boiling and splashing of slag. Iron oxide fume is given off to the furnace gases and comes in contact with the walls and roof. The oxidation reactions are exothermic and bath temperature rises sharply. The gas coming from the bath is almost entirely CO and unless the air supply to the furnace is increased or fuel input is cut, an almost reducing atmosphere can be created in the furnace combustion chamber. The CO burns in the combustion chamber as air reaches it, again raising furnace temperatures.

All of these reactions are very harmful to silica refractories. The furnace temperature is usually close to the melting point of silica when oxygen is added. The furnace temperature increase which results from the oxygen addition can easily exceed the limits for silica brick. In some cases, "burning" of a silica roof has been observed with oxygen blowing even though the fuel input was completely stopped. The additional fluxing of the slag splash and the iron oxide fume also speed the refractory melting action. Further, in reducing atmosphere, the refractoriness of silica in the presence of iron oxide drops sharply.

As a result, in many cases, the use of bath oxygen has been confined to periods when bath carbons are low to decrease the effect of these reactions. Greater use of oxygen would materially increase production speed.

In other cases, basic panels have been inserted in silica roofs at the worst wearing areas to achieve longer roof life because the basic brick are much more resistant to this type of wear (130).

With all-basic furnaces, bath oxygen can be used more extensively without overly adverse effect. The reactions caused by use of bath oxygen do accelerate wear of basic roofs as well as silica, but if the oxygen additions are localized in certain areas, the greater wear is limited and repairs are minimized. This practice appears to have been used successfully in one operating all-basic furnace. The use of the all-basic furnace in conjunction with the use of large amounts of oxygen in the bath, appears highly desirable, if not necessary, to obtain reasonable refractory life.

Improvement of furnace productivity related to furnace availability—The steady productive operation of a furnace has obvious effect on the overall productivity of the unit. Longer refractory life with less frequent rebuilds and hot repairs, is the prime means of achieving this end. Another major factor is the speed of repair operations when such procedures are necessary (131–136, incl.). The use of the all-basic furnace provides notable improvement in comparison with silica furnace practice.

To show the overall effect of the all-basic furnace with its longer refractory life on furnace availability and corresponding productivity, it is necessary to examine the various furnace sections separately and show the comparison of basic vs silica for each. Experience has shown that unit roof life of a 15-in. thick basic roof incorporating all the known good features of refractories and construction, already described, is over three times greater than that of silica roofs for the same furnaces. This proportion has been verified in several different open hearth operations, including both cold metal and hot metal practices. In such operation, relatively little hot repairing of the roof is normally required. Thus the period that the furnace is not available for operation because of the roof is virtually only that required for major rebuilding. Comparison of campaign length of such basic roofs with silica yields ratios slightly lower than the unit roof life comparison. This figure will vary to some extent in shops with different operations, rebuilding and patching practices. However, for general estimating purposes, a ratio of three to one is not unreasonable. In this event, the time required for two silica roof rebuilds, plus that normally expended in patching three silica roofs, would be utilized productively through the use of a basic roof.

In all of these data, it should be remembered that the all-basic furnaces are being operated in ways that would destroy silica furnaces rapidly. For example, in one case, where an all-basic furnace had been operated for some time, a silica roof was installed and operated under the same practice as the previous basic roof. The furnace production rate was good as long as it ran. This was for only 80 heats and to get this life enough patching was required to bring the unit roof life figure to only about 38. Comparing on this basis, basic outlasts silica almost 10 to 1.

Campaign lengths of basic roofs may be expected to extend from something over 300 heats to as much as 700 heats or more, in American furnaces, depending upon individual shop practice. When the longer campaigns are obtained, it is sometimes necessary to shut the furnace down during the run to clean slag pockets and flues. Such shutdowns normally last only 24 to 48 hours. They also provide time for careful replacements of front and back walls and any patches to ends or roof that might be needed.

Repairs to front walls and back walls are one of the major time losses with the all-basic furnace. With silica furnaces, these are usually accomplished coincident with roof patches or replacements and cause little time loss themselves. With basic furnaces, front and back wall repairs use time that would otherwise be productive. However, with judicious use of water cooling, life can be extended so that this time requirement is not onerous. Time required for front and back wall repairs can usually be kept below 36 to 48 hours during a period of up to 400 to 500 heats.

By correct use of basic checkers, with proper blowing practice and, in some cases, soot blowers beneath them, the downstairs of a furnace can be kept in good operating condition throughout the campaign of a basic roof. As mentioned above, a clean-out of slag pockets or some flue sections might be needed, but the regenerator chambers and checkers themselves should cause no difficulty.

Some further experience is needed to achieve balance of life in the various sections of basic furnaces. Arrangements for such balance (i.e., relation of end wall or port roof thickness and life to main roof life, etc.) are usually different for each different furnace. Most of the present all-basic furnaces have not yet achieved optimum conditions in this regard. The results obtained show more

repair hours during campaigns than is expected in the future.

Overall, on the basis of results to date, the down hours for brick repair and clean out during a basic furnace campaign, are extremely low. In one instance, a furnace had only slightly over 100 hours downtime for such work in a campaign of almost 700 heats (almost 10 months operation).

Major rebuilds of all-basic furnaces should not take as long as complete rebuilds of silica furnaces, once the teardown and rebuilding operations are as well known and are organized as thoroughly as silica repairs. However, new practices always need "shake down" time before they reach top efficiency. Much of the data now available on this subject show longer periods than will be needed in the future in the same shops.

There are several characteristics of all-basic furnaces which make this faster rebuilding possible. First, the brick requirement for an all-basic structure may be only about 60 per cent of that required when silica brick is used. This is particularly true when small furnace ends are used. With this smaller brick installation, mason hours diminish and total elapsed time should decrease. Secondly, with suspended construction, so that each furnace section is independent of others for support, only those furnace parts actually worn out need be replaced. This also decreases bricklaying time. Teardown of the smaller structures should also proceed at a faster pace. The advantage of basic ends in aiding slag removal is widely recognized. Overall rebuilding of all-basic furnaces should be rapid.

The small amount of rebuilding and repair of all-basic furnaces makes them particularly attractive to smaller steel plants which have relatively small maintenance crews to perform repairs. Other plants which have labor shortage also find this characteristic of all-basic furnaces extremely helpful in maintaining high availability.

There is somewhat slower operation in the laying of basic roofs as compared with silica roofs. In the actual bricklaying of most suspended basic roofs, a scaffold is built inside the furnace so that the bricklayers can hang the brick from the steel superstructure. The brick must be supplied to the bricklayers through the furnace door openings. Floor operations occasionally can interfere with this procedure, causing delays.

First, a ring of brick is installed across the furnace, usually at the tap hole position. Then additional rings of brick are hung towards both ends of the furnace. With this arrangement, only about eight bricklayers can work at one time. This is relatively slow procedure as compared with the laying of a silica roof, and is disadvantageous for this reason. The installation of a suspended basic roof by this method has frequently required about four working turns.

By laying of the brick on centers using brick with the tab hanger accommodation previously described, the actual bricklaying can progress virtually as rapidly as with silica brick. However, additional time is required for the installation of centers, which must be placed closer together than with silica brick, because of the greater weight of the basic brick. More time is required for the attachment of the brick to the steel superstructure, and removal of the centers. If this work can progress while other work of the furnace rebuild is progressing, it seems possible that this procedure could result in an overall time saving.

A somewhat slower heating schedule is also desirable for all-basic roofs. Some data indicate that silica roofs can be heated to charging temperature in as little as 14 hours (137). With basic roofs, heating of the roof at a rate of about 100 F per hour throughout the heat-up has given good results. This requires 24 to 30 hours for heating to charging temperature.

It is interesting to note that the heating up procedure recommended in Europe for the European style construction and refractories (58) entails considerable work. Essentially, it consists of measuring the position of the arch in the cold condition and maintaining this position within about five mm by adjustment of the pressure bolts on the skewback springs. As many as 11 different steps are taken to accomplish this, covering a period of six to eight weeks. The recommended heating schedules require as much as four to six days to reach charging temperature.

Combining the effects of normal rebuilding, heating up and necessary repairs during the course of a campaign, major increase of operating time can be expected over silica furnace operations with all-basic construction. It appears likely that something over 95 per cent availability can be realized.

The time requirement for converting an existing silica furnace to all-basic construction may be greater than that of a complete silica replacement depending upon the changes to furnace steelwork required. However, if change of steelwork for the silica furnace is needed, this is not necessarily true.

A recent conversion was accomplished in about 14 days, fuel off to fuel on, and in 15 days steel to steel. Another conversion was accomplished in just over three weeks with a much smaller labor force working two ten-hour shifts each day.

Considering the improvement in basic furnace productivity, the idea that immediate production demands prevent taking a furnace from operation long enough to make the conversion, does not appear reasonable. It is conservatively estimated that with the increased melting rate and greater availability of the all-basic furnace, any production loss entailed in the conversion of a silica furnace would be recovered completely within 60 to 90 days.

Where completely new installation or major rebuilding programs are being considered, there is no time deficit in connection with the construction of an all-basic furnace. In view of this, such programs are admirably suited for the adoption of all-basic construction.

General discussion of all-basic furnace operations—In view of the complexity and interrelation of the many factors affecting operations of individual all-basic furnaces, it is extremely difficult to present a concise and clear comparison of all-basic versus silica furnace operations.

In general, the productivity of all-basic furnaces is a minimum of 10 per cent greater than comparable silica furnaces, although increase of 25 per cent or more is possible in some cases. This improvement results both from faster melting and increased furnace availability.

With regard to fuel consumption, the all-basic furnace can equal, or better, the rates of comparable silica furnaces. The fuel saving can amount to 5 to 10 per cent.

In achieving these results, the all-basic furnace does not operate faster automatically. Neither does it inherently provide good fuel practice. It merely permits the use of practices which promote such results. However, the all-basic furnace enhances the value of such practices.

Among the more important practices which have helped to give these good results and offer even greater potential achievements, are the use of high rate of fuel input, improvement of design of furnace ends, and increase of air preheat temperatures. The results of work on these, and other practices, for increasing furnace productivity, have been essential to the success of the all-basic furnace. The ultimate benefits that can be attained through its use are still to be learned.

THE ECONOMY OF THE ALL-BASIC OPEN HEARTH FURNACE

In the foregoing discussions many of the various factors which affect cost data have been discussed individually, but with little reference to the absolute costs. The life of basic roofs is about three times that of silica. Basic ends have life of as much as two to three times that of basic roofs. Basic checkers outlast fireclay in varying amount, dependent upon operating conditions, and provide other advantages. Construction labor requirements for all-basic furnaces are less than for silica furnaces. Fuel consumption of all-basic furnaces can be made equal to or below those of silica furnaces. Furnace productivity of all-basic furnaces is materially higher than that of silica furnaces. Additional intangible factors, such as the decrease in probability of expensive, unscheduled repairs provided by suspended construction or the increase in earning power of a given unit with increased productivity also contribute materially to the economy of the all-basic furnace. However, these factors must be related to costs per ton.

In comparing the refractory costs per ton of ingot for the all-basic furnace and the silica roof furnace, the first factor is the relative cost of basic brick and silica brick. On a piece price basis, the basic brick cost about 4.5 times the cost of silica brick, f.o.b. manufacturing plant. Freight charges will vary depending on plant location.

These figures do not mean that to use basic refractories economically it is necessary to obtain life improvement in the same ratio. Installed cost of refractories includes both brick cost and labor. The manhours of refractory construction and repair are substantially less per campaign with the all-basic furnace. However, it is difficult to indicate comparable installed costs which are universally applicable for all-basic versus silica constructions. In general, the ratio of installed costs is less than 3 to 1.

All-basic furnace operations appear to verify that if roof life is about three times greater than silica, the cost per ton of product is about equal to that of silica. It seems logical that such data for other furnace parts would follow in line.

With regard to fuel cost, all of the presently operated furnaces have shown figures equal to, or better than, comparable silica furnaces when good combustion practices have been followed. It now seems assured that the fuel cost for all-basic furnaces is at least as low as that for silica furnaces and that with the adoption of combustion practices which are feasible only with all-basic construction, the fuel costs can be lowered to values below those possible with silica furnaces.

The increased productivity of all-basic furnaces decreases fixed overhead costs on a per ton basis. The amount of this decrease is inversely proportional to the increase in productivity. Since increases of productivity of from 10 to 25 per cent may be expected with all-basic furnaces, a proportionate decrease in overhead per ton can be expected.

None of the above discussion of cost elements takes into account the value of the increased amount of product of the all-basic furnace. An increased production rate of 10 per cent can represent an additional earning power for a given furnace equivalent to $1.00 per ton of its total product.

This factor of increased earnings with increased productivity has been neglected in many cases, because it has been said that it applies only in times of peak production. This is not entirely true. With virtually every major steel company embarking on programs for increase of steel production capacity, and every indication of high continuing need of high production rates, this factor of increased earnings should be included in the evaluation of the all-basic furnace. The early acceptance of this factor in Europe probably explains the quicker success of the all-basic furnace there.

In America, with the improvement in refractory life realized with internal plated brick and improved construction techniques, with decrease of fuel costs from improvement of operating and combustion practices, and with further increase of productivity decreasing overhead, the all-basic furnace is achieving lower cost per ton figures than comparable silica furnaces.

With this achievement, the economic advantage of the all-basic furnace is obvious once the furnace is an operating entity. The problem becomes one of the advantage of the all-basic construction on an investment basis; that is, the cost of converting a furnace to all-basic construction as compared with the return it will produce.

Such studies vary widely, because of the differences in present constructions in various plants and the differences in amount of new basic construction required for conversion to an all-basic installation.

In general, it appears that the conversion of a silica roof to an all-basic roof for a 200-ton furnace costs about $60,000 to $70,000 without bricklaying labor for the initial installation, and about $35,000 to $40,000 without bricklaying labor for each replacement. Comparable costs for silica replacements approach $15,000. Differentials of $15,000 to $25,000 in initial brick costs, plus from $10,000 to $25,000 for initial changes to furnace steelwork, are not unusual for large furnaces. The cost of changing the steel is non-repetitive. For any individual case, it is necessary to obtain more exact estimates. These can readily be made.

Basic ends can usually be installed in a conversion to basic construction for about $40,000 to $50,000 more than a normal silica furnace rebuild (which would probably include substantial amounts of basic brick). Replacement costs are less. The economy of the basic end structures is demonstrated by their wide acceptance.

They are, of course, essential to the use of the all-basic roof. They prove their worth with basic roofs as they do with silica.

The installation costs of basic checkers vary widely with the amount of basic brick to be used. As the use of basic checkers is increased, more cost data will become available. Some users have reported that costs of basic checkers are about equal or below those of fireclay checkers (61). However, the use of basic checkers seems, at present at least, more involved with improvement of combustion and production and with extending furnace life than with cost savings per se.

The extra cost for all-basic construction is much less if new furnaces are being considered instead of conversion of existing furnaces. In this case, the extra initial cost for basic is normally only the difference between basic and silica replacements. The advantage of institution of all-basic constructions on new furnace installations is obvious.

In this connection, on planning new open hearth installations, the greater unit productivity of the all-basic furnace permits substantial decrease in capital investment. For properly designed new installations, production advantage of 20 per cent for basic over silica does not seem an extravagant estimate. On this basis, five basic furnaces would produce as much steel as six silica furnaces.

In view of all the foregoing factors, the overall economic picture of the all-basic furnace appears very encouraging with properly adjusted conditions. A basic furnace should pay off the extra cost of the initial construction or conversion within one campaign. This would be within a period of about six months to a year. From that time forward, corresponding savings would accrue. If comparison is made only on the basis of operating costs per ton, a longer period is needed to pay off the initial investment. However, with the present high demand for steel, this relatively easy means of obtaining additional salable product is highly attractive.

GENERAL SUMMARY

1. The development of the all-basic furnace in Europe and America progressed by rather divergent paths. The all-basic furnace first attained success in Europe, but many of the ideas which came from the American developments are now incorporated in European all-basic furnaces. To a lesser extent, European ideas have been used here. Now the all-basic furnace is recognized as successful on both continents.

2. Good refractories for all the parts of all-basic furnaces have been developed. A new type of internally plated basic brick and other design changes have materially improved the service life of the brick and all-basic furnaces.

3. Good principles of all-basic furnace construction provide a minimum of compressive force on the refractories and a minimum of movement of the refractories. These can be achieved through the use of suspension, the absence of corbelled surfaces, proper expansion provisions and allowance for roof growth by spring supported skewbacks. There are several different workable designs which may be used for such all-basic construction. These designs vary in their ability to meet the requirements of the refractories. Selection of the best design for the individual case should be made on the basis of good construction principles in the light of immediate requirements.

4. Much of the success of the all-basic furnace has been attained through the use of improved operating practices. Many such practices used commonly on all-basic furnaces would have disastrous effects on silica furnaces.

All-basic furnaces can produce from 10 to 25 per cent more steel than comparable silica furnaces, with fuel consumption from 0 to 10 per cent less than the silica furnaces. The increased productivity results from both the faster melting and from the greater availability possible with all-basic furnaces.

The operating and combustion practices which have been most important in producing the high productivity and low fuel consumption for all-basic furnaces include:

a. Increase of fuel input.
b. Maintenance of high fuel input throughout the complete melting period.
c. The adoption of furnace chamber and port designs which promote rapid combustion and high temperature flames.
d. Improved control of combustion for hotter flames.
e. Use of oxygen for combustion.
f. The increase of air preheat temperature.
g. Increases of furnace hearth area and/or heat size upon rebuilding.
h. The increase in use of oxygen for decarburization.

More work on these and other operating practices can promote still further increase in productivity of the all-basic furnace.

With regard to increased availability of open hearth furnaces for increased production, the all-basic furnace, including main roof, ends and basic checkers, provides:

a. Roof life about three times that of silica with few repairs required.
b. Port end life of from two to three times that of basic roofs with little repair requirement.
c. Regenerators that stay efficient and open throughout the furnace run.
d. A small brick requirement for overall construction, thus shortening construction time.
e. Rapid tear-down of the smaller furnace sections when repairs are necessary.
f. Easy and rapid slag removal as compared with silica furnaces.
g. Independent support of the various furnace sections so that only completely worn out parts need be replaced, thus cutting down repair time.

If all the various procedures for improving furnace production were applied to one all-basic furnace, the possibility of 6-hr heats, with reasonable refractory life, does not appear impossible.

5. The properly handled all-basic furnace operates with refractory costs equal or lower than those of silica, with equal or lower fuel costs, and with decreased overhead charges. The net effect is a decrease in cost per ton of ingots. In addition, the value of the increased earnings as a result of the increased productivity of the all-basic furnace, is a substantial figure.

The all-basic furnace marks an important step forward in the history of steel making.

BIBLIOGRAPHY

1. "*Trends in Refractories for the Basic Open Hearth Furnace*," by R. P. HEUER, Metals and Alloys, April and May, 1940.
2. "*Basic Ends and All-Basic Open Hearth Furnaces*," by R. P. HEUER and M. A. FAY, 1948 Proceedings AISE.
3. "*Modern Refractories Give New Operating Economies*," by R. P. HEUER and M. A. FAY, Iron Age, October 6, 13, 1949.
4. "*The All-Basic Furnace . . . European and American*," by R. P. HEUER and M. A. FAY, Journal of Metals, June and July, 1950.
5. "*Refractories for the Open Hearth Roof*," by R. E. BIRCH, AIME Open Hearth Proceedings, 1944, pp 310–313.
6. "*Development of Basic Open Hearth Roofs*," by R. P. HEUER, AIME Open Hearth Proceedings, 1944, pp 337–338.
7. "*The Outlook for an All-Basic Open Hearth Furnace*," by R. B. SOSMAN, AIME Open Hearth Proceedings, 1945, pp 54–68.
8. L. F. REINARTZ, Discussion, AIME Open Hearth Proceedings, 1945, p 71.
9. "*Developments in Unburned Magnesite Brick for the Metallurgical Industry*," by A. E. FITZGERALD, Mining and Metallurgy, Dec. 1941.
10. "*A New Application for the Ritex Process to the Manufacture of Chrome Brick*," by R. P. HEUER, Steel, Aug. 19, 1935.
11. "*Refractories from a Metallurgical Viewpoint*," by G. E. SEIL, Industrial Heating, September, 1935.
12. "*The Noranda Smelter*," by BOGGS and ANDERSON, Trans. AIME, Vol. 106, 1933.
13. "*The Flin Flon Copper Smelter*," by AMBROSE, Monthly Bulletin, Canadian Inst. of Mining & Metallurgy, No. 281, Sept., 1935.
14. R. P. HEUER, U. S. Patent No. 2,154,813.
15. "*Discussion of Suspended Basic Roofs*," by E. F. REINARTZ, H. S. ROBERTSON, R. P. HEUER, R. E. GRIFFITH, G. E. SEIL and H. A. MORLOCK, AIME Open Hearth Proceedings, 1939, pp 82–89.
16. L. A. SMITH, Discussion, AIME Open Hearth Proceedings, 1941, p 32.
17. "*Combination Basic and Silica Open Hearth Roof Construction*," by C. G. POTH, AIME Open Hearth Proceedings, 1941, pp 142–150.
18. "*Survey of Zebra Roofs in Use in the U. S. and Canada*," by T. H. HARLEY, AIME Open Hearth Proceedings, 1952, pp 94–97.
19. "*Zebra Type Open Hearth Roof Steps up Heats Per Campaign*," by C. E. GRIGSBY, Steel, May 7, 1951.
20. "*A Survey of Zebra Roof Practice*," by C. E. GRIGSBY, Journal of Metals, Feb., 1952.
21. "*Discussion of Basic Roofs*," by L. A. SMITH, H. C. COULSON and H. M. GRIFFITH, AIME Open Hearth Proceedings, 1943.
22. H. M. KRANER, Discussion, AIME Open Hearth Proceedings, 1945, p 70.
23. "*Installation of Basic Open Hearth Roof*," by H. S. FRANK, AIME Open Hearth Proceedings, 1944, pp 334–337.
24. "*Basic Open Hearth Installation at Ford Motor Co.*," by H. S. FRANK, AIME Open Hearth Proceedings, 1945, pp 45–47.
25. "*Basic Open Hearth Installation, Ford Motor Co.*," by W. J. REILLY, AIME Open Hearth Proceedings, 1947, pp 209–210.
26. W. S. DEBENHAM, Discussion, AIME Open Hearth Proceedings, 1944, p 339.
27. A. E. REINHARD, Discussion, AIME Open Hearth Proceedings, 1949, p 51.
28. "*Basic Roofs—Current and Prospective Applications*," by H. M. GRIFFITH, AIME Open Hearth Proceedings, 1944, p 332.
29. "*Progress Report on Basic Roofs and Port Ends*," by H. M. GRIFFITH, AIME Open Hearth Proceedings, 1945, p 37.
30. "*Progress Report on Basic Furnace Construction*," by A. K. MOORE, AIME Open Hearth Proceedings, 1946, p. 262.
31. "*Basic Ends and Basic Roofs*," by A. K. MOORE, AIME Open Hearth Proceedings, 1947, p 206.
32. "*Construction of Basic Ends and Main Roof for Open Hearth Furnaces*," by A. K. MOORE, AIME Open Hearth Proceedings, 1948, p 164.
33. "*The All-Basic Furnace in Canada*," by A. K. MOORE, AIME Open Hearth Proceedings, 1949, pp 147–149.
34. "*Progress Report on All-Basic Furnace at Steel Company of Canada*," by A. K. MOORE, AIME Open Hearth Proceedings, 1950, p 219.
35. "*Design of All-Basic Open Hearth*," ANON., Iron & Steel Engineer, Oct., 1947.
36. "*Basic Construction at South Works*," by M. F. YAROTSKY, AIME Open Hearth Proceedings, 1948, pp 174–175.
37. "*The All-Basic Furnace at South Works*," by M. F. YAROTSKY, AIME Open Hearth Proceedings, 1949, p 179.
38. "*Progress Report on All-Basic Furnace at South Works, Carnegie-Illinois Steel Corporation*," by M. F. YAROTSKY, AIME Open Hearth Proceedings, 1950, p 217.
39. "*Some Factors Affecting Open Hearth Practice*," by D. J. CARNEY, J. J. ORAVEC and E. VAN METER, Journal of Metals, January, 1955.
40. "*Operation and Performance of All-Basic Furnace at South Works*," by J. F. O'BRIEN and J. J. ORAVEC, Presented at Chicago Local Section AIME Open Hearth Conference, Feb., 1955.
41. "*Capacity Gains, Fuel Savings, Push All-Basic Open Hearth*," ANON., Iron Age, Sept. 22, 1955, p 114.
42. "*All-Basic Furnace Construction at Keystone Steel & Wire Co.*," by A. H. SOMMER, AIME Open Hearth Proceedings, 1955, p 84.
43. "*General Discussion on the Use of Basic Brick for Technical Committee on Open Hearth Steelmaking*," by A. H. SOMMER, Regional Meeting of the American Iron & Steel Institute, Jan. 27, 1956.
44. "*Use of Basic Brick in Europe as Compared with Use in the United States*," by A. H. SOMMER, Southwestern Section Meeting, AIME Open Hearth Conference, Kansas City, Mo., Feb. 10, 1956.
45. "*General Use of Basic Refractories in European Open Hearth Practice*," by A. H. SOMMER, AIME Open Hearth Proceedings, 1956.
46. "*All-Basic: All for Keystone*," ANON., Iron Age, May 10, 1956, p 57.
47. "*No. 25 Gets New Flat Roof; Object: More Steel Quicker*," ANON., The Inland Steelmaker, Jan. 19, 1956.
48. "*New Flat Topped Roof Doing Fine*," ANON., The Inland Steelmaker, Apr. 26, 1956.
49. "*Beitrag zur Technik der Magnesitanwendung*," by L. HUTTER, Radex Rundschau, Heft 2, 1950.
50. "*Open Hearth with Basic Roof*," by L. B. LINDEMUTH, Iron Age, Nov. 6, 1941, pp 47–54, Nov. 13, 1941, pp 44–49.
51. T. P. MANN, Discussion, AIME Open Hearth Proceedings, 1945, p 68.
52. "*The All-Basic Open Hearth Furnace*," by J. H. CHESTERS, Iron Age, Aug. 15, 1940, pp 35–37, Aug. 22, 1940, pp 39–41.
53. Special Report (1938), Iron & Steel Institute, pp 22, 69, 80–81, Fig. 5.
54. G. E. SEIL, Discussion, AIME Open Hearth Proceedings, 1946, p 269.
55. R. P. HEUER, U. S. Patents No. 2,289,911 and 2,087,107.
56. R. P. HEUER and M. A. FAY, U. S. Patent No. 2,652,792.
57. H. M. DAVIS, Discussion, AIME Open Hearth Proceedings, 1945, p 71.
58. R. B. SNOW, Discussion, AIME Open Hearth Proceedings, 1945, p 71.
59. "*Basic Brick Vs. Design in Checker Brick Efficiency*," by C. E. GRIGSBY, The Glass Industry, April, 1941.
60. "*Special Refractories for Checker Brick*," by C. C. BENTON, AIME Open Hearth Proceedings, 1955, pp 109–112.
61. C. C. BENTON, AIME Open Hearth Proceedings, 1956.
62. A. H. SOMMER, AIME Open Hearth Proceedings, 1956.
63. "*The Operation and Refractory Life of All-Basic Open Hearth Furnaces*," by L. HUTTER, Radex Rundschau, Heft 1/2 January, 1954.
64. "*Developments in Basic Refractories for Copper Furnaces*," by A. E. FITZGERALD, Journal of Metals, 1956.
65. R. P. HEUER, U. S. Patent No. 2,547,322.
66. "*Basic Knuckles*," by H. L. TEAR, AIME Open Hearth Proceedings, 1955, p 102.
67. "*Iron & Steel, The Present*," ANON., Iron Age, June, 1955, D-10.
68. "*Physical and Mechanical Aspects of Combustion*," by G. E. SEIL, AIME Open Hearth Proceedings, 1944, pp 59–73.
69. "*Analysis of Open Hearth Literature from the Viewpoint of Combustion Engineer*," by ROBERT NOOR, AIME Open Hearth Proceedings, 1944, pp 76–87.
70. Discussion of Paper (No. 68 in this Bibliography), by R. B. SOSMAN, AIME Open Hearth Proceedings, 1944, pp 141–142.
71. "*Operation of Oxygen Enriched Open Hearth Furnaces*," by J. S. MARSH, AIME Open Hearth Proceedings, 1948, pp 43–56.
72. "*Significance of Air Temperature in Open Hearth Operations*," by J. S. MARSH, Yearbook of the American Iron and Steel Institute, 1951, pp 185–200.
73. "*Tapping Heats Through Bifurcated Spouts Into Two Ladles*," by E. C. SORRELS, AIME Open Hearth Proceedings, 1954, pp 63–65.
74. "*Tapping Double Heats at Sparrows Point*," by J. H. KELLEY, AIME Open Hearth Proceedings, 1954, pp 66–67.
75. "*Bifurcated Spouts*," by H. H. NORTHRUP, AIME Open Hearth Proceedings, 1954, pp 67–69.
76. "*Effect of Charging Rate on Production*," by V. W. JONES, AIME Open Hearth Proceedings, 1946, pp 32–35.
77. "*Preparation and Charging of Scrap*," by CLYDE DENLINGER, AIME Open Hearth Proceedings, 1947, pp 53–55.
78. "*Factors Affecting Basic Open Hearth Operating Rates*," by OSCAR PEARSON, AIME Open Hearth Proceedings, 1948, pp 74–84.

79. *"Methods for Improving Charging,"* by R. R. Fayles, AIME Open Hearth Proceedings, 1948, pp 102–109.
80. *"Scrap Charging—Key to Increased Open Hearth Production,"* by R. R. Fayles, AIME Open Hearth Proceedings, 1949, pp 24–34.
81. *"Factors Affecting Open Hearth Production in Gas Fired Furnaces,"* by S. F. Elam, AIME Open Hearth Proceedings, 1949, pp 87–92.
82. *"Evaluation of Factors Influencing Open Hearth Production in Oil Fired Furnaces,"* by A. P. Woods, AIME Open Hearth Proceedings, 1949, pp 93–101.
83. *"Scrap Preparation and Charging Practice,"* by Various Discussers, AIME Open Hearth Proceedings, 1949, pp 130–142.
84. *"Methods of Increasing Inland Steel's Open Hearth Production,"* by G. C. Lawton, AIME Open Hearth Proceedings, 1941, pp 43–50.
85. *"Fuel Consumption in the Open Hearth Furnace,"* by A. J. Fisher, AIME Open Hearth Proceedings, 1950, pp 268–275.
86. *"Furnace Design for Increased Production,"* by D. J. Loughrey, AIME Open Hearth Proceedings, 1951, pp 93–98.
87. *"Furnace Design for Increased Production,"* by J. M. Brashear, AIME Open Hearth Proceedings, 1951, pp 98–101.
88. *"Furnace Design and Shop Arrangement for Increased Production,"* by J. L. Hyland, AIME Open Hearth Proceedings, 1951, pp 102–107.
89. *"Effect of Restricted Uptake Design on Refractory Consumption and Production Rate,"* by E. B. Speer, AIME Open Hearth Proceedings, 1953, pp 111–119.
90. *"Flame Radiation and Open Hearth Productivity,"* by M. W. Thring, Journal of the Iron and Steel Institute, October, 1954, pp 165–169.
91. *"Anatomy of the Open Hearth,"* by J. S. Marsh, Journal of Metals, April, 1955, pp 545–554.
92. *"Use of Oxygen in Basic Furnace,"* by M. F. Yarotsky, AIME Open Hearth Proceedings, 1948, pp 34–35.
93. *"Increasing Firing Rates,"* by H. S. Hall, AIME Open Hearth Proceedings, 1948, pp 66–68.
94. *"Use of Multiple Burners to Improve Operating Rates of Open Hearth Furnaces,"* by Umbert F. Corsini, AIME Open Hearth Proceedings, 1948, pp 70–73.
95. *"Optimum Firing Rates,"* by G. C. Primm, AIME Open Hearth Proceedings, 1950, pp 277–282.
96. *"Relation of Flame Radiation to Open Hearth Operation,"* by A. J. Fisher, AIME Open Hearth Proceedings, 1944, pp 91–136.
97. *"Use of Oxygen in Open Hearth Furnaces,"* by J. J. Golden, AIME Open Hearth Proceedings, 1947, pp 68–73.
98. *"Use of Oxygen in Open Hearth Furnaces,"* by J. S. Marsh, AIME Open Hearth Proceedings, 1947, pp 73–74.
99. *"Use of O_2 at East Works, American Rolling Mill Co.,* by H. V. Flagg, AIME Open Hearth Proceedings, 1947, pp 74–76.
100. *"Use of O_2 (or Compressed Air) in The Open Hearth Furnace,"* by F. G. Norris, AIME Open Hearth Proceedings, 1948, pp 35–41.
101. *"Oxygen Through the Burner at Granite City,"* by R. C. Solomon, AIME Open Hearth Proceedings, 1948, pp 88–90.
102. *"Metallurgical O_2 in Cold Metal Shops,"* by L. L. Whitney, AIME Open Hearth Proceedings, 1948, pp 91–95.
103. *"Progress Report on Use of Metallurgical Oxygen,"* by P. W. Nutting, AIME Open Hearth Proceedings, 1950, pp 43–48.
104. *"Increase of Ingot Production by Use of Oxygen,"* by E. H. Leathers and C. W. Drabers, AIME Open Hearth Proceedings, 1951.
105. *"Use of O_2 for Flame Enrichment and Decarburization,"* by A. M. Kroner, AIME Open Hearth Proceedings, 1952, pp 59–66.
106. *"Methods of Obtaining Rapid and Efficient Heat Transfer from Flame to Metal Bath in the Open Hearth Furnace,"* by F. N. Hays, AIME Open Hearth Proceedings, 1944, pp 88–90.
107. *"Furnace Design for Cold Metal Shops,"* by O. P. Leutscher, AIME Open Hearth Proceedings, 1949, pp 142–147.
108. *"Flow and Velocities of Air and Waste Gases,"* by H. V. Flagg, AIME Open Hearth Proceedings, 1950, pp 253–260.
109. *"Flow Patterns in Open Hearth Furnace,"* by J. H. Chesters, AIME Open Hearth Proceedings, 1951, pp 282–306.
110. *"Effects of Uptake Dimensions on Furnace Performance, Inland Steel Co.,"* by L. R. Berner, AIME Open Hearth Proceedings, 1952, pp 281–283.
111. *"Effect of Restricted Uptake Design on Production Rate and Refractory Consumption,"* by M. J. Smith, AIME Open Hearth Proceedings, 1953.
112. *"Modified Slopes on Port Roofs,"* by P. W. Nutting, AIME Open Hearth Proceedings, 1955, pp 95–97.
113. *"Ein Neues Profil Fur Den Herdraum des Siemens-Martin-Ofens,"* by F. Bartu and E. Boelens, Stahl and Eisen 76 (1956) No. 3, 9 Feb.
114. *"Elimination and Control of Air Infiltration,"* by H. M. Parker, AIME Open Hearth Proceedings, 1951, pp 295–296.
115. *"Checker Maintenance to Increase Flame Intensity,"* by L. A. Hovey, AIME Open Hearth Proceedings, 1952.
116. *"Significance, Factors Affecting and Methods of Measuring Air Preheated Temperatures,"* by H. S. Hall, AIME Open Hearth Proceedings, 1952, pp 244–250.
117. *"Factors Involved in Maintenance of Air Preheat,"* by J. H. Kelley and G. E. Wenzel, AIME Open Hearth Proceedings, 1953, pp 181–184.
118. *"Auxiliary Stack Checkers,"* by C. N. Straney, AIME Open Hearth Proceedings, 1953, p 161.
119. *"Measurement and Influence of Preheated Air in the Open Hearth Furnace,"* by W. P. Cashmore, Journal of the Iron and Steel Institute, Oct. 1954, pp 112–121.
120. *"Regenerator Efficiency and Air Preheat in the Open Hearth,"* by B. M. Larsen, Journal of Metals, Feb., 1954.
121. Discussion of J. S. Marsh Paper (see No. 72), by H. S. Hall, Yearbook of the American Iron and Steel Institute, 1951, pp 201–203.
122. *"Selection of Checker Brick From a Thermal Viewpoint,"* by J. Lamont, Glass 13 (3), pp 114–118 (1936).
123. *"The Influence of Material, Shape and Size of Checker Brick on Heat Transfer in Regeneration,"* by J. D. Keller, Journal of the American Ceramic Society, 1937, pp 144–155.
124. *"Use of Oxygen in Hot Metal for Agitation of the Bath,"* by H. E. Warren, Jr., AIME Open Hearth Proceedings, 1947, pp 27–33.
125. *"Use of O_2 for Carbon Reduction in Cold Metal Practice,"* by H. M. Parker, AIME Open Hearth Proceedings, 1948, pp 96–97.
126. *"Use of Metallurgical O_2 at American Steel Foundries,"* by C. C. Whitney, AIME Open Hearth Proceedings, 1949, pp 150–155.
127. *"Use of O_2 Jets Through the Backwall,"* by A. E. Reinhard, AIME Open Hearth Proceedings, 1950, pp 43–48.
128. *"O_2 for Carbon Reduction and Temperature Pickup,"* by E. H. Reyer, AIME Open Hearth Proceedings, 1950, pp 111–113.
129. *"O_2 for Increasing Open Hearth Production, Gary Steel Works,"* by W. C. Buford, AIME Open Hearth Proceedings, 1952, pp 66–70.
130. *"Carbon Removal with Roof Mounted O_2 Jets in Open Hearth Furnace,"* by J. E. Hood, Journal of Metals, April, 1956, pp 418–419.
131. *"Use of Mechanical Equipment,"* by Various Discussers, AIME Open Hearth Proceedings, 1944.
132. *"Handling of Refractory Materials,"* by I. C. Johnston, AIME Open Hearth Proceedings, 1948, pp 57–59.
133. *"Availability of Open Hearth Furnaces, Sparrows Point Plant,"* by R. M. Baker, AIME Open Hearth Proceedings, 1951.
134. *"Use of Basic Brick to Increase Furnace Availability,"* by S. J. Dougherty, AIME Open Hearth Proceedings, 1951, pp 80–81.
135. *"Scheduling and Planning Furnace Repairs,"* by J. L. Walton, AIME Open Hearth Proceedings, 1952, pp 104–106.
136. *"Scheduling Open Hearth Rebuilds,"* by J. O. Dague, AIME Open Hearth Proceedings, 1952, pp 106–110.
137. *"Heating Up Open Hearth Furnace After Rebuilds,"* by C. N. Jewart, AIME Open Hearth Proceedings, 1953, pp 202–209.

DISCUSSION

PRESENTED BY

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M. J. SMITH, Superintendent Open Hearth, Ford Motor Co., Dearborn, Mich.

A. H. Sommer: The authors of this paper should be commended for the extensive study and complete history they have given on the various phases of the use of basic brick in open hearth furnaces. They have outlined the general progress that has been made in such

a way that one can take advantage of past experience in planning for the future in regard to the more general use of basic refractories throughout the entire open hearth system, including the regenerators. The general practice at Keystone, where we are operating with 30 per cent pig iron and 70 per cent steel scrap as a cold charge, definitely indicates that a basic roof and basic ends should be augmented by the use of basic brick in the fantail and regenerative system.

At Keystone Steel & Wire Co., we are operating one all-basic furnace with a flat roof and a single uptake and another furnace which has two uptakes and an arched contour in the roof. The latter furnace was described in their paper; however, due to our limited experience with the Maerz furnace, we have not drawn any conclusions as to the best type of construction. We feel that it is reasonable to expect at least 700 heats as a major campaign on this type of furnace, and I think this concurs with the authors conclusion that, the roof life when using basic refractories should be at least three times that of a silica roof. Our present thinking at Keystone in regard to roof construction is that some type of ribs should be used, even though the roof is 100 per cent suspended, in order to obtain greater stability when the roof gets thin and to simplify the repair work. We have not proved the overall economics in regard to an all-basic furnace; but we do concur with the authors in that when maximum output of the open hearth department is essential to full operations in other departments, including making deliveries to customers, the higher availability and increased production will more than justify a slightly higher refractory replacement cost.

The authors conclusion that, "The all-basic furnace marks an important step forward in the history of steelmaking," we feel is still somewhat contingent on the manufacturers continued cooperation toward further improving basic brick to be used in various parts of the open hearth furnace. They have given us a very constructive report on the all-basic furnace which I am sure will be helpful to the steel industry.

B. L. Dorsey: The question that arises in my mind is why has it taken twelve years to arouse the interest of more than a few American steel producers, particularly, when many European steel producers have been successfully using this type of construction for many years.

The obvious and correct answer is the economics of this construction over conventional construction. We have been more fortunate in having the highest quality of silica refractories available and the difference in normal operating service between these was not of sufficient magnitude to justify the basic roof in most American plants.

However, the necessity for more production per unit has resulted in changes in operating practices which are detrimental to the conventional refractories. The increased fuel inputs are also resulting in less efficient combustion which produce atmospheres that are detrimental to all refractories at elevated temperatures, but more so to the conventional ones. The lessened life of the conventional furnaces under these conditions makes it easier to justify the all-basic furnace. Again, the increased use of oxygen for decarburization and/or combustion has had a similar detrimental effect on many of the conventional refractory furnaces.

The idea of the internal plated basic brick has been a means of partially overcoming the platy spalling generally found in basic brick where temperature changes are rapid or great. It reduces the cross sectional area of the face of the basic refractory and allows greater temperature changes before the thermal stresses set up exceed the strength of the brick of smaller cross-section. The application of the type of refractory to the all basic furnace has been one of the reasons for the increased interest.

With the additional all-basic furnaces in American service I feel sure that a definite trend will be established in the near future and the question most of us would like to have answered now will have to wait for that time.

Robert P. Gibson: If the internal plates have created the advantage that you claim, and I will go along with the fact that they have helped, are two plates, for example, in the brick the limit to which you can get advantage, or do you intend to eventually use more internal plates in the hope of further improving the product?

M. A. Fay: It is possible to use more than two plates. The data recorded in our paper are based only on the use of either a single plate or two plates. Further experiments will be made in line with the general development.

M. J. Smith: Is anyone who is using oxygen lances through the open hearth furnace roof using patches of basic brick around them?

M. A. Fay: There has not been enough work on the use of oxygen in this way to determine exactly what roof construction will be used. In general, though, we are inclined to feel that the use of a fully suspended, complete, basic roof will probably be the best answer for this practice.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

By FRANK J. MARKEY, Manager, Edge Position Controls Div., Askania Regulator Co., Chicago, Ill.

Edge Position Control for the steel strip industry

. . . . many forms and many designs are used for automatic edge position control on continuous processing lines . . . . certain design details apply to all applications and these are covered in this paper, particularly with respect to payoff and wind-up reels . . . .

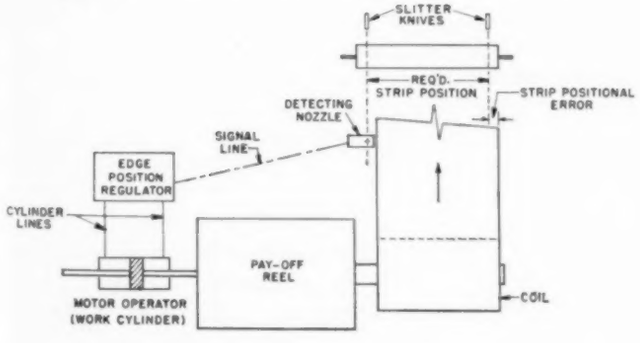
▲ON modern steel strip processing lines, edge position control no longer is regarded as an accessory but is considered an important part of the continuous processing system. For years, mechanical means of guiding strip have been used on process lines. In more recent years, non-contact edge control systems have been used to greater advantage because the edge of the strip is not damaged by contact edge guiding. This is particularly important on light gage steel or on steel that has been coated, such as galvanized steel.

It is the author's intention to discuss in this paper details that should be considered in the design of a continuous process line when edge control is applied to either the pay-off or wind-up reels, or at some other intermediate point within the process.

EDGE POSITION CONTROL SYSTEM

A basic edge position control system is depicted in Figure 1. This is a typical pay-off reel application ahead of a slitter or side trimmer. The object in this application is to position the strip to line up properly for the slitter knives. The amount the actual strip position is offset from the required strip position will be referred to as the "strip positional error" or "strip error."

Figure 1 — Schematic shows a basic edge position control system



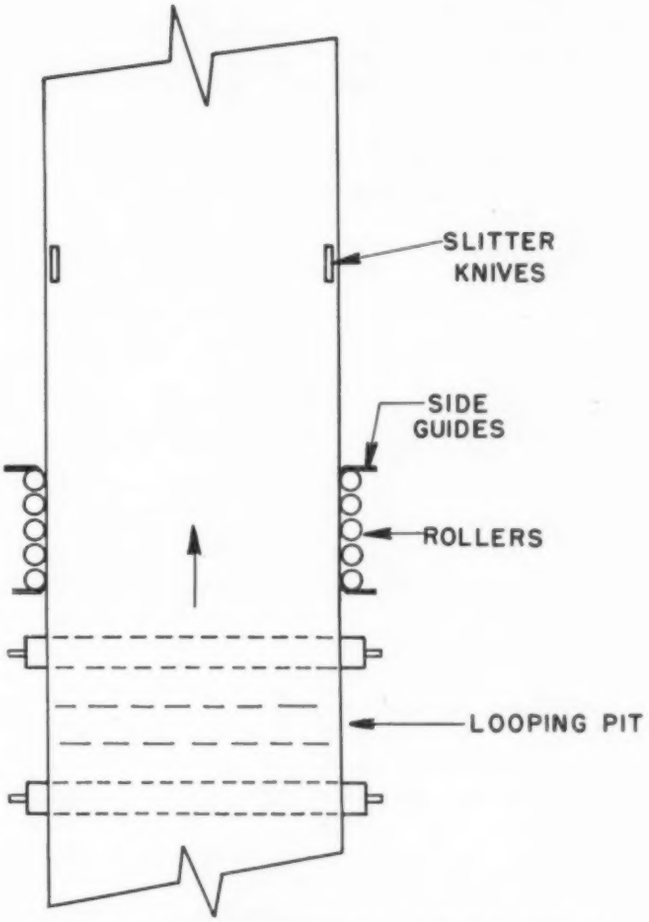


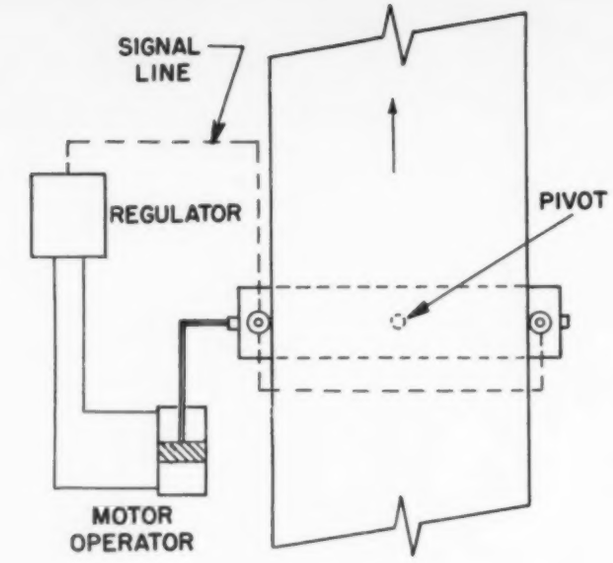
Figure 2 — This system uses mechanical side guides.

The purpose of the edge controller is to correct for strip positional errors. The edge position detector will detect strip position and the edge position controller through the motor operator (or work cylinder), will move the pay-off reel to position the strip as required.

TYPES OF EDGE POSITIONING DEVICES

The following are some of the types of edge positioning devices known to the author:

1. Mechanical side guides (Figure 2).
2. Electric or pneumatic contact rollers with roll shifting devices (Figure 3).



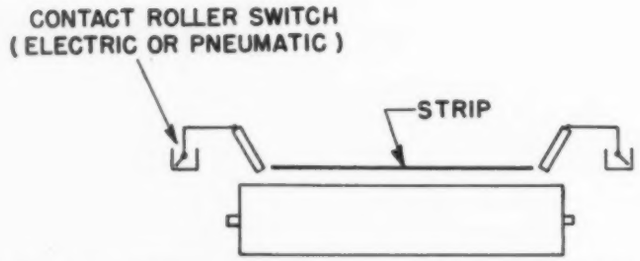


Figure 3 — Contact rollers have a roll shifting device in this scheme.

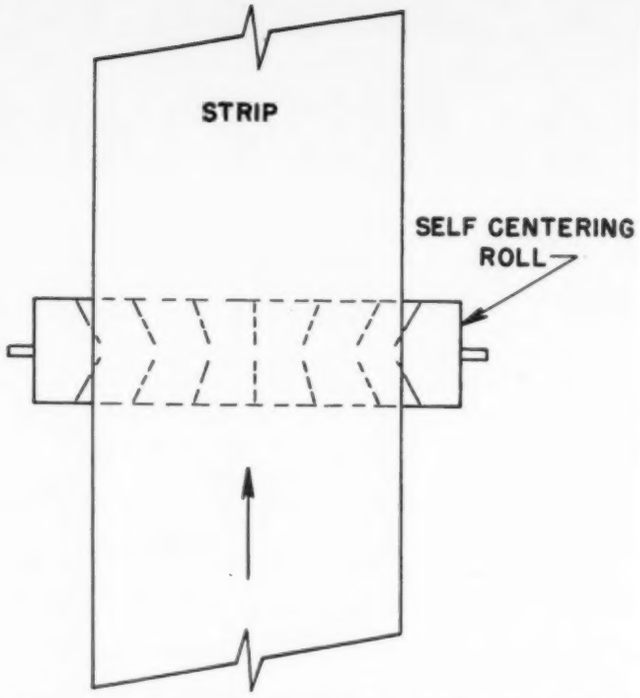


Figure 4 — Self-centering rolls may be used to keep strip in alinement.

3. Self-centering rolls (Figure 4).
4. Electric non-contact scanning detector with hydraulic or electric motor operator (Figures 5 and 6).
5. Pneumatic non-contact detector with hydraulic motor operator (Figure 7).

All of the methods enumerated above will produce some sort of edge guiding, however, some of them have definite limitations which could be described as follows:

1. *Mechanical side guides*—Mechanical side guides are generally used ahead of slitter knives or similar applications. In most cases, it is necessary to have a looping pit ahead of the side guides and bring the strip up slack in order to prevent damage to the edge. With this method, it is difficult to run telescoped coils at high speeds. Therefore, production output of the line is comparatively low.

Mechanical side guides have a definite place in continuous process lines since they represent a positive method of guiding the strip.

2. *Contact rollers*—In this method, a contact roller is used to trip an electric or pneumatic switch when engaged by the strip, which drives a pivot roll in one direction or the other. The contact roller is located immediately outside of the usual strip pass line. This is considered an "on-off" control system, since the correcting roll is moved from one of two fixed positions to the other.

Since the pivot roll is turned in one extreme direction or the other each time a correction is made, the strip continually wanders back and forth. This system is not satisfactory for high-speed process lines because there is a considerable time lag before the strip responds to movement of the pivot roll.

The contact roller system has an advantage over the mechanical side guide system. Since the engagement of the strip with the contact roller is light, it is not likely that damage will occur to the edge of the strip. On slow moving process lines, and when the strip positional error is not too great, this method represents an economical way of edge position control.

3. *Self-centering rolls*—Self-centering rolls (Figure 4) are used primarily on continuous processing lines to keep the strip edge tracking. It is recognized that they have definite limitations since they depend on constant tension of the strip in order to make the guiding effective. It is not practical to use self-centering rolls on the entry end of the process line if the coils on the pay-off reel are greatly telescoped.

In order to keep the strip tracking the centering rolls are an essential part of the continuous process line. They are easy to install and are usually located at a point in the process where optimum surface contact between the strip and the roll can be made.

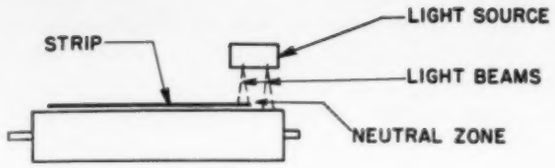
4. *Electric non-contact scanning systems*—The electric non-contact edge guiding systems can be divided into two classes:

a. On-off control system (Figure 5).

This system employs two light beams with a neutral zone between them. One beam must be covered and the other uncovered. If not, an electric motor drives the reel either mechanically or hydraulically in the direction to move the strip and uncover or cover respective light beams. This correction occurs at constant speed.

b. Floating control system (Figure 6).

Floating control requires a more complex system than the two-position or on-off control. However, with this system, the rate of correction of the motor operator,



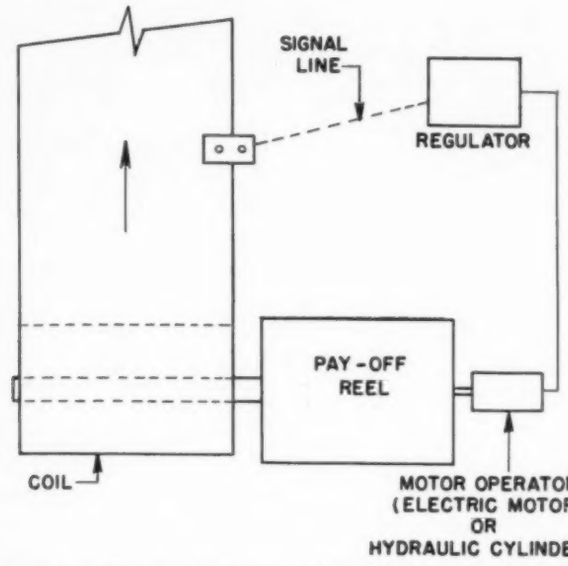


Figure 5 — Non-contact scanning detector may also be used for edge position control.

whether mechanical or hydraulic, is in proportion to the magnitude of strip positional error. This system can be adjusted so that hardly any dead zone exists; hence, the strip is under continuous control.

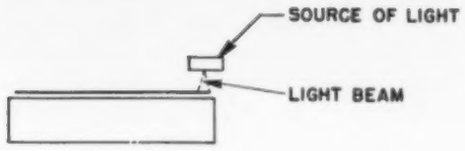
Both of the above systems have a decided advantage over all the others previously mentioned, since in detecting strip position, no contact with the strip edge takes place and consequently, no damage occurs. The on-off control system is economical for a slow moving process line. The floating control system is more satisfactory for high speed lines since the rate of correction decreases as the strip approaches the required strip position. This avoids hunting or overshooting of the system, and a more accurate control can be obtained.

5. *Pneumatic non-contact hydraulic system* (*Figure 7*)—This system is similar to the floating electric scanning system inasmuch as the rate of correction of the motor operator is in proportion to strip positional error. The two systems, in most respects, are identical, except for the method of applying correction at the motor operator. The advantages of this system are much the same as those of the floating electric scanning system.

Much time could be spent in discussing all the advantages and disadvantages of the above systems. Since space is limited, it is the author's intention to discuss specifically the pneumatic-hydraulic system employed by our company. Furthermore, the author is more familiar with this system and is able to present detailed information pertaining to its operation.

PNEUMATIC-HYDRAULIC CONTROL SYSTEM

The pneumatic-hydraulic control system (Figure 7) is composed of three main separate units listed below:



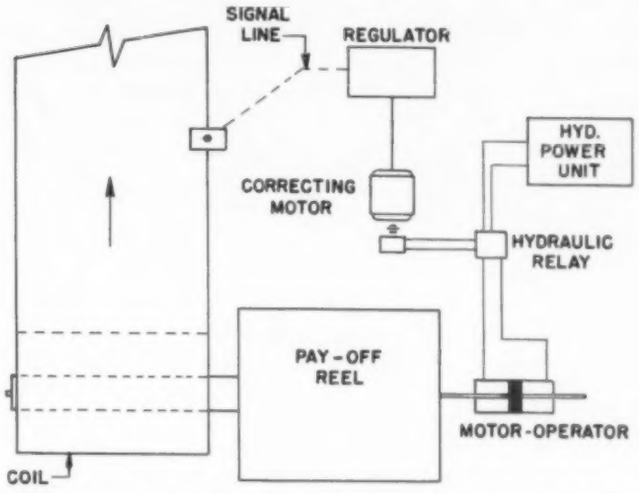


Figure 6 — Schematic shows float control type of electric scanning edge position control.

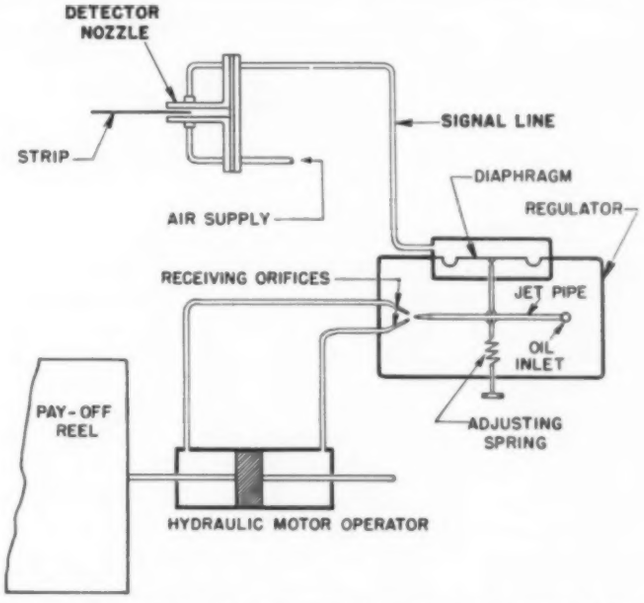


Figure 7 — Schematic shows pneumatic non-contact edge position control system.

1. The air pressure detecting nozzle.
2. The edge position regulator including the hydraulic power unit (pump unit).
3. The hydraulic control cylinder (motor operator).

1. The air pressure detecting nozzle is the detecting element which continuously senses the strip edge position. The nozzle consists of two slotted orifices facing one another, one termed the "supply orifice" and the other the "recovery orifice." Both are held in a universal mounting bracket to insure proper alinement. The orifices are spaced approximately 1½ in. apart, and the steel strip passes approximately mid-way between them. Plant air is connected to an air pressure reducing

valve and then to the supply orifice of the sensing nozzle. The air supply pressure is reduced such that a 4-in. water column air pressure at the recovery receiving orifice is obtained when the supply orifice is completely uncovered. Figure 8 shows a curve indicating pressure recovery related to orifice opening. Note that if the orifice opening is half covered, the recovery pressure is half of the pressure obtained at fully uncovered position. The recovery pressure changes are practically linear in relation to orifice opening.

2. The edge position regulator consists of a swinging jet pipe which discharges, at high velocity, a jet of oil at two closely spaced orifices. These openings are connected to the ends of a work cylinder.

Two forces act on the jet pipe. On the right hand side is the diaphragm system and on the left is an adjusting (or setting) spring. When the diaphragm force and the spring force are in balance, an equal rate of oil flow is discharged at both orifices and equal pressures exist in each line, hence, the forces at each end of the work cylinder are equal.

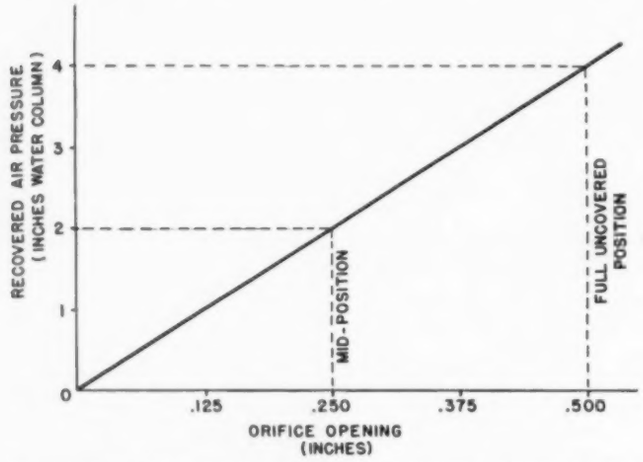


Figure 8 — Air pressure recovery increases directly with orifice opening.

With a condition as mentioned above, the jet pipe is in its mid-position, and the system is considered to be in a neutral position. The jet pipe, through the diaphragm system, responds to pressure signal changes received from the air pressure detecting nozzle and moves to the right or left. Direction of movement of the jet pipe depends on the magnitude of the pressure signal, whether it is greater or less than the spring force.

3. The hydraulic work cylinder is the motor operator. The force due to the differential pressure across the piston moves either the pay-off or the wind-up reel, or a strip steering device.

HOW THIS SYSTEM WORKS

In all control systems, three main components can be distinguished, namely, the primary or detecting element, the regulator, and the motor operator. In the edge position control system, the detecting element is the air pressure detecting nozzle, and the hydraulic work cylinder is the motor operator. It is interesting to note that in the edge control system, the steel strip displacement introduces an error to the system and the motor operator restores the strip to its original position. Therefore, the strip is responsible for a disturbance in the system and yet acts as the final control element when the motor operator restores it to a neutral position.

Referring to Figure 7, the signal pressure changes detected by the nozzle are transmitted to the diaphragm system on the edge position regulator. The jet pipe responds to signal changes and moves to one side or the other discharging oil through the oil distributor plate to the work cylinder. We have already seen in Figure 8 that the recovery air pressure at the sensing nozzle is a 4 in. water column with the orifice area completely uncovered and a 2 in. water column with half of the orifice area covered.

Therefore, if the spring adjuster is set at a 2 in. water column while the steel strip is covering half of the orifice area of the air detecting nozzle, the two forces acting on the jet pipe are equal and the regulator is in a neutral position. No action of the motor operator (cylinder) occurs.

If the strip moves to the left uncovering more of the orifice area, the diaphragm force is greater than the spring force, the jet pipe moves to the left, and the work cylinder moves in the direction that will return the strip edge to the center of the orifice opening of the detecting nozzle. If the strip moves to the right covering more orifice area, the spring force is greater than the diaphragm force and a reverse action from that mentioned above occurs.

In summarizing the above, it can be said that any lateral strip positional change detected at the sensing nozzle results in a pressure signal change on the edge position regulator, followed by a correction through the motor operator which restores the strip to its neutral position.

SELECTING SYSTEM COMPONENTS

We have already seen that the edge position control system is composed of three parts, namely, the edge position detector, the regulator, and the hydraulic work cylinder. In all applications, the edge detector remains the same. The edge position regulator, the hydraulic power unit and the hydraulic work cylinder vary in size according to the particular application. The important considerations that determine the size of these components are:

1. Type of application (wind-up reel or pay-off reel).
2. Total weight of reel and carriage to be moved.
3. Type of reel mounting (e.g. bronze versus steel ways, lubricated).
4. Estimated force needed to overcome static friction.
5. Forward strip speed (fpm).
6. Diameter of coil.
7. Expected amount of error per lap (for a pay-off reel) or expected amount of error in ten feet (for a wind-up reel).

The above information makes it possible to proceed with the selection of the hydraulic work cylinder, hydraulic power unit, and edge position regulator.

On pay-off reel applications, the amount of telescoping of the coils to be run is the determining factor of the required rate of correction. On wind-up reel ap-

plications, the expected amount of strip weave at the tension reel determines the required rate of correction.

Hydraulic work cylinder—In selecting the hydraulic work cylinder, two important considerations are:

1. Total weight to be moved.
2. Estimated force required to move the load from a standing position.

Since the force required to start the reel moving is greater than that required to keep it in motion, the coefficient of static friction is an important figure for consideration. Movable reels are frequently mounted on lubricated bronze versus steel ways. The coefficient of static friction, however, varies greatly from one reel to another. Contributing factors to this variance are: type of lubrication, atmospheric dust, humidity, surface finish, temperature, vibration and the extent of contamination of the surface. There appears to be a general agreement that a book could be written on this subject. If the reel in question is available, it is possible to determine the coefficient of friction with the aid of a hydraulic pump and pressure gage as illustrated in Figure 9. The pump discharge pressure is changed in small increments, a visual inspection of the pressure gage is made and the minimum pressure required to start the reel moving is recorded. Thereupon, the coefficient of static friction is computed as follows:

$$\frac{P \times A}{\text{Total weight moved}}$$

where P = psi indicated on gage just as reel starts to move
A = area of piston, in sq in.
Weight moved = total weight of reel and coil, in pounds

It is recognized that in most cases it will not be possible to make a test such as this, particularly if a new reel is being designed. Therefore, it is necessary to depend on an estimate figure for calculations. Most engineers usually know what figure to suggest for all practical purposes.

Since this figure varies among design engineers, the author made several field tests using methods similar

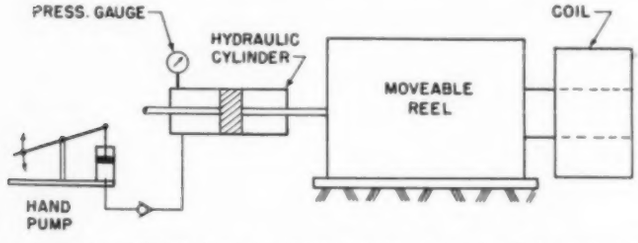


Figure 9 — Coefficient of static friction can be determined by method indicated.

to that illustrated in Figure 9 to determine whether a consistent coefficient of static friction could be obtained.

All tests were made on reels that were mounted on lubricated sliding ways, bronze versus steel. The lowest figure of coefficient of static friction obtained was 0.175 and the highest was 0.375. From this information, the author decided that for his future calculations in estimating the size of the hydraulic work cylinder, a satisfactory rounded-off figure for use as the coefficient of static friction would be 0.4. This figure allows a slight margin of safety in case any error was made in computing the weight to be moved.

After the size of the hydraulic work cylinder is determined, careful consideration should be given to the mounting and the type of connection between the piston rod and moving reel. It is extremely important that all lost motion between the piston rod and moving reel be kept to a bare minimum. Any loss of motion encountered at this point introduces a lag in the system, which results in a continuous overshooting or hunting.

In selecting the type of hydraulic cylinder, it is the author's suggestion that a double-ended cylinder be considered, as it has inherently the same rate of correction in both directions because of equal effective piston areas. In all control systems, a final adjustment is usually made to obtain optimum results, and if the rate of correction is different in each direction, it is difficult to arrive at a final adjustment.

Hydraulic power unit—Once the hydraulic work cylinder size is established, the maximum rate of correction required of the final control element can be determined. This is computed in in. per sec of piston displacement of the hydraulic work cylinder. From this information, the total cubic displacement is calculated establishing the output requirements of the hydraulic power unit. The operating pressure of the hydraulic oil supply should be determined before selection of the hydraulic cylinder size. This is usually in the neighborhood of 600 or 700 psi.

Views on the rate of correction required for various applications vary considerably. It is the author's experience that the maximum rate of correction required is frequently over-estimated, resulting in a design that has a correction rate twice as great as required.

On wind-up reel applications, it is difficult to predict the expected amount of strip weave since many factors contribute to this, such as misalinement of idler rolls, wear of the equipment and, of course, the camber of the strip itself. In all cases, it is expected that the strip will track on down through the process and reach the wind-up reel without too much deviation. However, as mentioned before, since other factors contribute to the strip weave, the rate of correction necessary for various types of wind-up applications is best obtained from experience tables. It is the author's experience that in general, wind-up reel applications can be classified in four categories and the maximum correction rate for each would be as follows:

Strip speed, fpm	*Rate of correction, in. per sec.*
5– 200	¼
200–1000	¾
1000–2500	1
2500–4000	1½

Unlike wind-up reel applications, on pay-off reel applications if the designer is familiar with the coil stock that will be run, there is a more accurate method of calculating the maximum rate of required correction. Figure 10 depicts a typical telescoped coil. The outside diameter is 48 in. and the inside diameter 18 in. An examination of this coil would determine the maximum error per lap that exists.

After the maximum rate of error per lap is deter-

mined, the rate at which the laps will occur must be calculated. It can readily be seen that if the coil diameter is 48 in., the rate of correction necessary is less than when the coil diameter is at its minimum. For this reason, we should decide on an average coil diameter on which to base our calculations. It is general practice for steel strip line operators to slow the line down as the tail end of the coil appears. Therefore, it is suggested that an average coil diameter of 36 in. be used in calculations.

If 36 in. is an average coil diameter, approximately ten feet will unwind per lap.

$$\frac{3.14 \times 36 \text{ in.}}{12 \text{ in. per ft}} = 9.42 \text{ ft}$$

Therefore, if the strip line is operating at 600 fpm, ten feet of strip will pass through the edge position detector each second.

$$\frac{600 \text{ fpm}}{60 \text{ sec per min}} = 10 \text{ fps}$$

If the maximum error per lap is $\frac{1}{4}$ in. then the maximum rate of correction will be $\frac{1}{4}$ in. per sec. From this figure, the required hydraulic oil delivery is determined.

Example

Line Specifications

Strip speed, fpm 1800
Expected error per lap, in. $\frac{1}{4}$
Diameter of cylinder, in. 8
Average coil diam, in. 36

Therefore, with an average coil diameter of 36 in., the length of approximately 10 ft per lap will unwind. Thus:

$$\frac{1}{10 \text{ ft per lap}} \times \frac{1800 \text{ fpm}}{60 \text{ sec}} \times \frac{1}{4} \text{ in. error per lap} = \frac{3}{4} \text{ in. per second correction rate required}$$

Hence, the necessary rate of oil flow to move the cylinder at the above rate is computed as follows:

Displaced cylinder volume in. per sec

$$= \text{Effective area of piston} \times \text{stroke per sec}$$
$$= \frac{\pi}{4} \times 8 \text{ sq in.} \times 0.75 \text{ in. per sec (disregarding piston and area)}$$
$$= 50.26 \times 0.75 \text{ cu in. per sec}$$
$$= 37.6 \text{ cu in. per sec}$$
$$= \frac{37.6 \text{ cu in. per sec} \times 60 \text{ sec per min}}{231 \text{ cu in. per gal}}$$
$$= 9.75 \text{ gpm}$$

The preceding information represents a method of calculating the rate of correction required when it is possible to examine the coil stock. However, in the design of new strip lines, it is not always practicable to examine the stock, and for this reason it is desirable to have some figure representing the expected amount of error per lap on a typical telescoped coil. With the cooperation of several steel mills, the author made an examination of coil stock on the floor on both tin and cold strip mills. In the tin mill coil stock, it was found that the average error per lap varied between $\frac{1}{16}$ and $\frac{1}{8}$ in., reaching approximately $\frac{1}{4}$ in. in a few cases. In cold strip stock, the average error varied between $\frac{1}{8}$ and $\frac{3}{16}$ in., with a maximum of $\frac{3}{8}$ in. per lap in a few cases. It is recognized that the expected amount of error for particular coils may vary considerably from the figures mentioned above, however, it is the author's belief that they represent average coil dimensions.

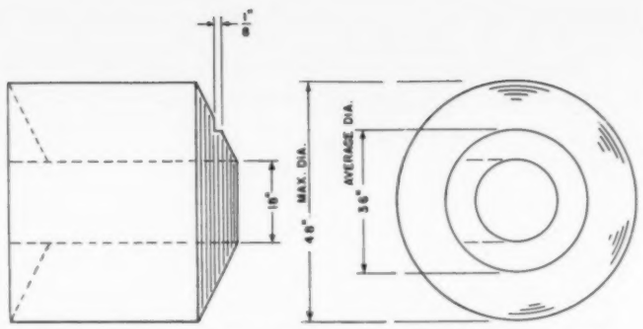


Figure 10 — Drawing shows a typical telescoped coil.

The edge position regulator—Once the hydraulic oil delivery rate (gpm) has been established, this information determines the size of the edge position regulator. In order to maintain the required rate of correction, the regulator must be so sized that the maximum rate of oil flow, at minimum pressure drop, is delivered to the motor operator.

APPLYING EDGE POSITION CONTROL TO THE PROCESS

In applying edge position control to the strip line process, serious consideration must be given to the location of the system components. Requirements of the pay-off reel applications are not the same as those of the wind-up reel applications. In fact, they are almost opposite. In the pay-off reel application, the strip is positioned by moving the reel, and every consideration must be given to the location of idler rolls in order that they do not interfere with strip movement. On wind-up applications, the wind-up reel is positioned to follow a strip weave. In moving the wind-up reel, the strip itself must remain in the same location on the idler roll, and the location of the idler rolls must prevent the strip from moving in a lateral direction.

Pay-off reel application—On the pay-off reel application, the detecting nozzle is in a fixed position, determined by the required strip edge position, and the strip is moved to the nozzle. In all control systems, the designer locates the system components so that a minimum time lag appears between the detected signal and a correction by the motor operator (work cylinder).

In the edge position control system, important considerations must be given to the location of the system components and their auxiliaries, such that correction of the strip and the pay-off reel movement is made simultaneously. The instant the reel is displaced, the strip must move and the detector must be aware of this movement. This is the most important condition in a stable control system. For this reason, the location of the detector nozzle, entry rolls, and pinch rolls affect the system response, which results either in a

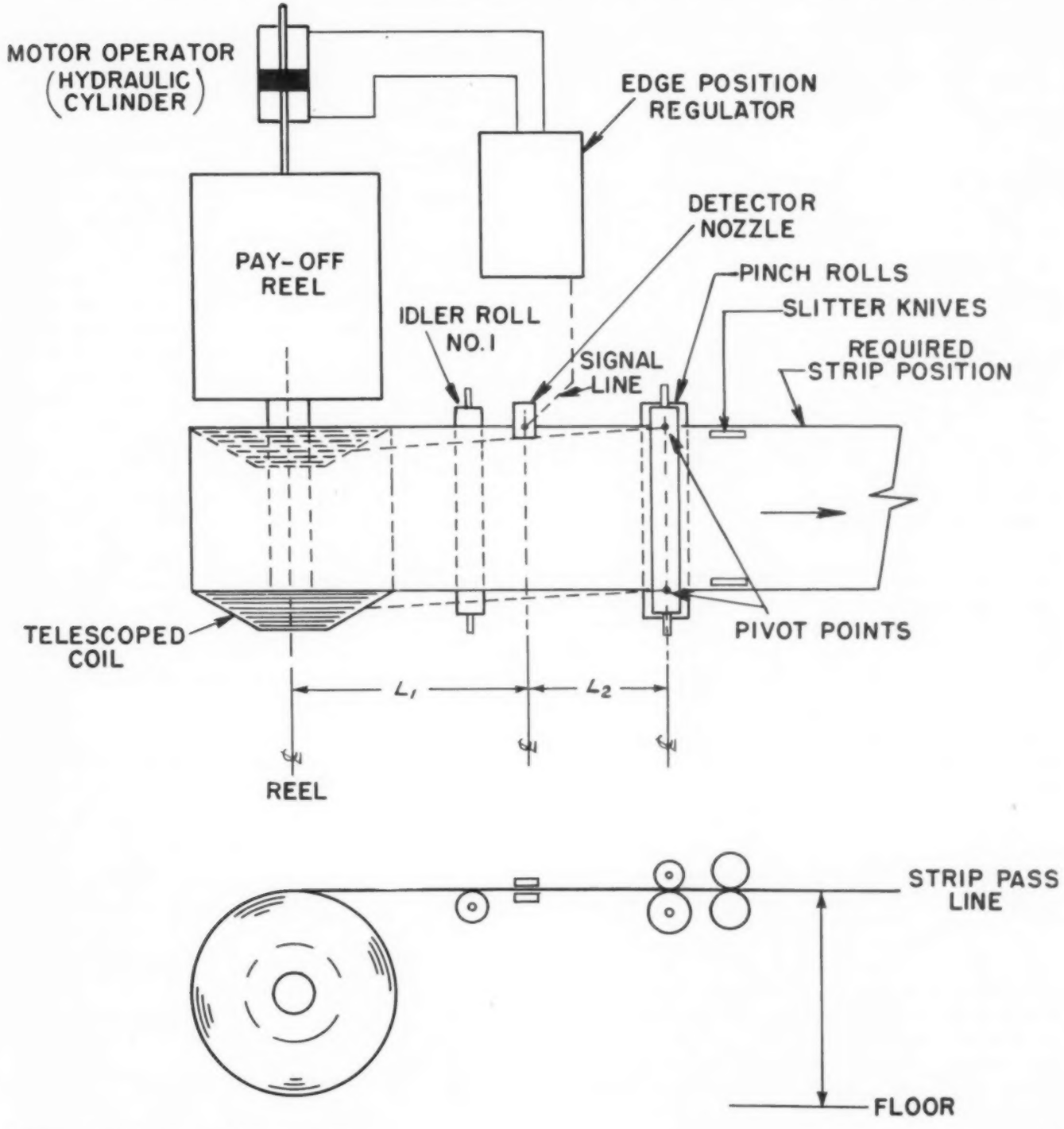
"stable" and "accurate" control or in an "unstable" and "inaccurate" control system.

Pinch rolls—In Figure 11 a typical pay-off reel application is depicted with an exaggerated telescoped coil on the reel. The reel continuously moves to the left to maintain the required strip position at the slitter knives. Since it is desirable not to have any weave at the slitter knives, an anchor or pivot point must be arranged before the knives. The pinch rolls, or in some cases drive rolls, act as this anchor point. If there are no pinch rolls ahead of the knives, the knives themselves provide a pivot point. However, if the process line is to be used as a combination slitter and re-run line, and the knives are not engaged with the strip on re-winding, then the strip would probably weave all the way down to the wind-up reel. In consequence, the pay-off reel will continuously move back and forth, the system will be unstable, the strip weave will upset proper tension at the wind-up reel, and the wound-up coil will not be satisfactory.

At this point, it should be mentioned that edge position control on the pay-off reel cannot be maintained satisfactorily unless there is constant tension of the strip beyond the pivot point.

Detector nozzle location—Let us assume in Figure 11 that no contact of the strip is made on idler roll No. 1 and the strip revolves about the pivot point at the pinch rolls. It can be seen that the magnitude of strip

Figure 11 — Operation of edge position control with telescoped coil on the payoff reel is shown by the diagram.



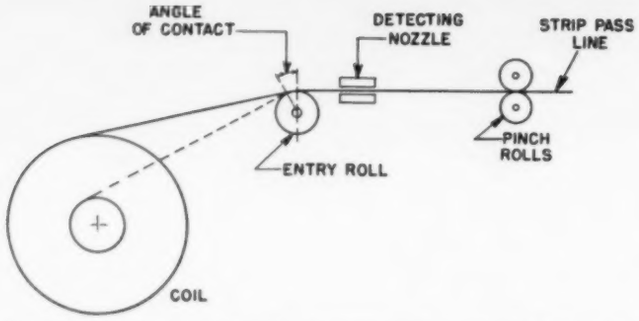


Figure 12 — Angle of contact may vary appreciably as the coil diameter changes.

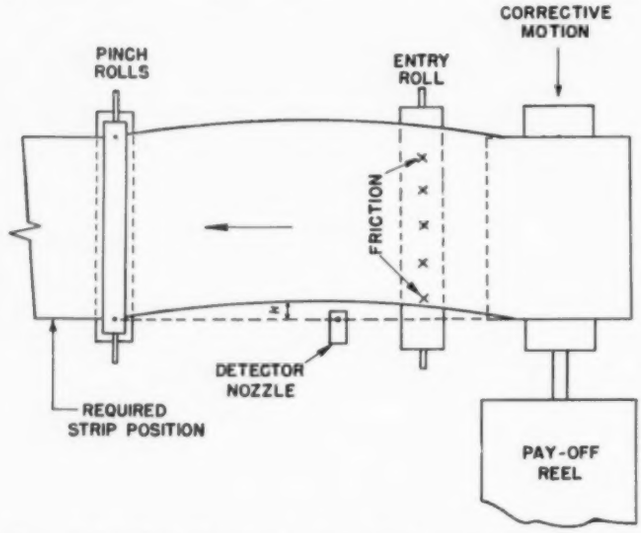


Figure 13 — Strip friction on entry roll must be considered.

displacement at the nozzle related to strip displacement at the reel is a function of the distances between the nozzle and the pivot point, and the reel and the pivot point. Thus:

$$\text{Strip displacement at the detector nozzle} = \frac{L_2}{L_1 + L_2}$$

The ideal arrangement would be to have strip displacement at the detector and reel equal in magnitude. The displacement could only be the same if the detector and reel were on the same centerline. Since the coil diameter continuously changes, this is not possible. An optimum solution is to locate the nozzle as close to the moving reel as possible.

Entry rolls—For satisfactory performance the detector nozzle must be located on a relatively constant pass line. Since, however, the coil diameter changes, an entry roll (or rolls) is required before the detector nozzle. If the coil diameter is large and the pay-off reel is located close to the entry roll, as shown in Figure 12, a considerable angle of contact of the strip on the entry roll is formed as the coil diameter decreases. This condition can cause a time lag in the system due to friction of the strip as it moves laterally across this roll.

As shown in Figure 13, the strip position at the reel can be ahead of displacement at the detector as much distance as $\times$ inches when a correction is made. With this condition, the strip edge at the reel always travels beyond the *required strip edge position* resulting in overshooting and continuous "hunting" of the system.

Corrective measures can be taken to (1) reduce the lag due to friction, and (2) eliminate it entirely.

Figure 14 illustrates a method of minimizing the angle of contact on the entry rolls. Two rolls with an $\frac{1}{8}$-in. spacer between them are located at an elevation such that contact is made with the upper roll at the start of the coil, and contact is made with the bottom roll at the tail end of the coil. For a few laps, at approximately mid-way through the coil, the strip does not contact either roll due to the spacer between them. For ease in threading the strip the top roll can be lifted by an hydraulic or air cylinder.

Figure 15 illustrates a method that eliminates any friction between the entry roll and the strip. In this design the entry roll (or rolls) moves with the pay-off reel. The detector nozzle is located close to the moving roll. Assuming there is no lateral slippage of the strip on the first idler roll, the ratio of strip displacement at the detector nozzle versus strip displacement at the reel becomes closer to 1:1.

It is known that designing a moving entry roll into a process line presents many mechanical problems, particularly if it is planned to feed the coil both from the top and bottom. However, on high speed process lines (above 1000 fpm) the author suggests that consideration be given to moving the entry roll, which presents a very important contribution to control system stability and accuracy. This is most important on light gage steel, since the rigidity of the strip is less than that of heavier gages, and lateral movement of the strip may cause it to buckle or wrinkle. A pay-off application on paper could not perform satisfactorily without moving the first entry roll, since the paper would wrinkle or in an extreme case it may tear.

Wind-up reel application—On the wind-up applica-

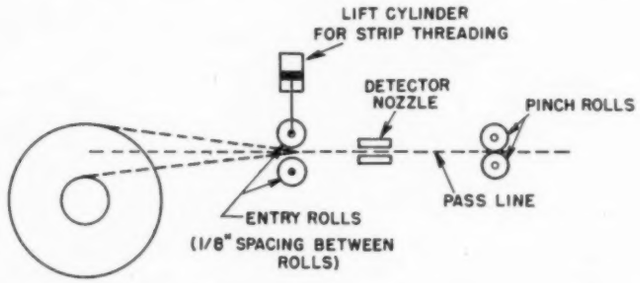
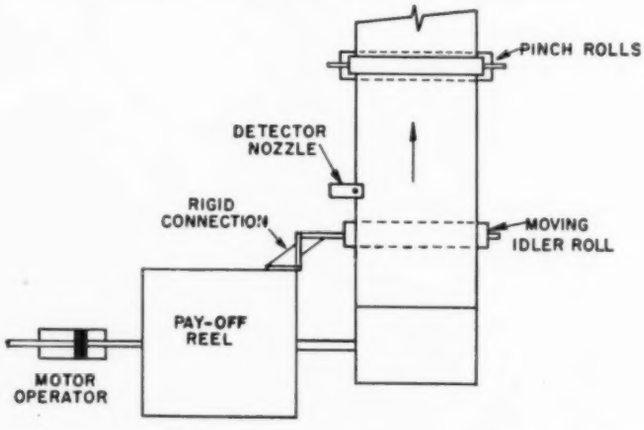


Figure 14 — Use of the double entry roll arrangement can reduce friction.

Figure 15 — Payoff reel has moving entry roll.



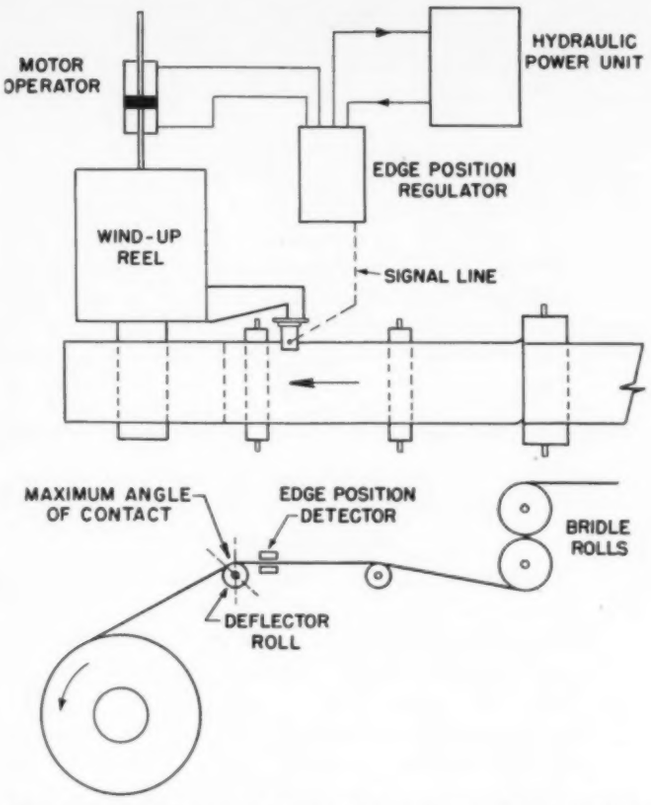


Figure 16 — Schematic shows edge position control applied to the wind-up reel.

tion, unlike the pay-off reel application, the reel follows the lateral strip travel and places the reel in proper position to receive the strip. This action is similar to that of a baseball player who moves his gloved hand into the path of the ball to catch it.

On the wind-up application, as shown in Figure 16, the detector is rigidly fastened to the reel and moves with it. The detector senses the strip edge lateral position, whereupon the automatic control system moves the reel to be in line with the strip. When a correction of the motor operator is made and the reel moves, the detector moves with it, until the system is restored to a neutral position.

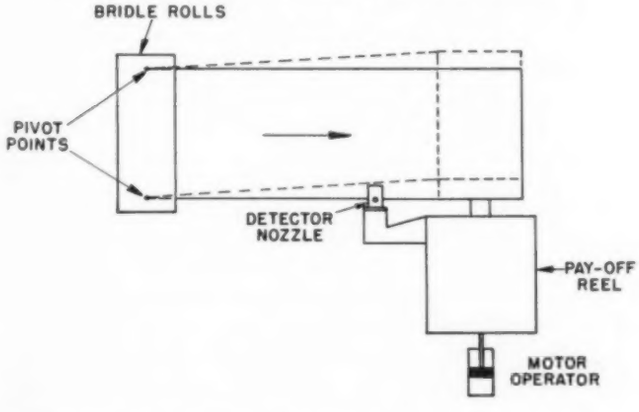
Since the detector is attached to the reel, the lateral motion between these two members is parallel. Idler rolls must be incorporated in the design of the process line, and suitably located to provide a maximum angle of contact with the strip, prohibiting strip displacement, when the reel moves. For example, as illustrated in Figure 17, if no deflector roll were to exist between the reel and bridle rolls the strip would pivot at the bridle rolls and the detector would never reach the strip edge in spite of its moving parallel with the reel. The control system would continually hunt.

Since satisfactory operation of the detector nozzle requires a constant pass line of the strip through the detector, the latter is located immediately ahead of the last stationary idler roll. This roll should have as much angular contact with the strip as possible in order that the strip be anchored and not move laterally when the reel moves.

The friction factor of steel versus rubber is considerably higher than that of steel versus steel. Therefore, if this roll is rubber-covered, the winding coil can slip under the steel strip without moving it on the surface of the deflector roll. This is the principle of a successful wind-up control operation.

It can be seen from the foregoing that:

Figure 17 — If no strip existed between the reel and bridle rolls, the strip would pivot at the bridle rolls.



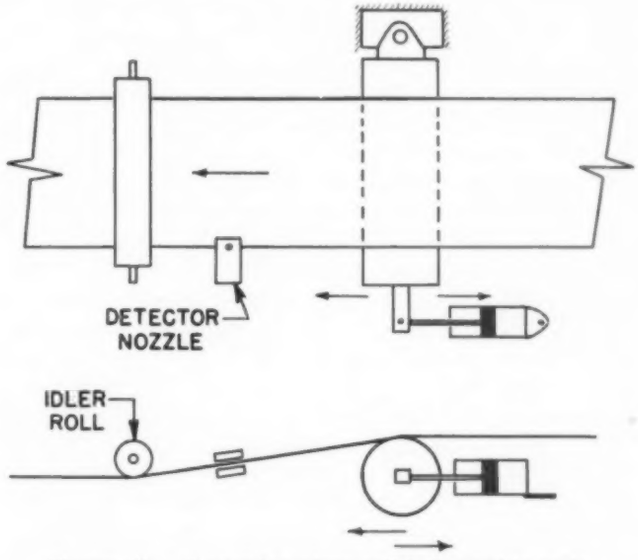
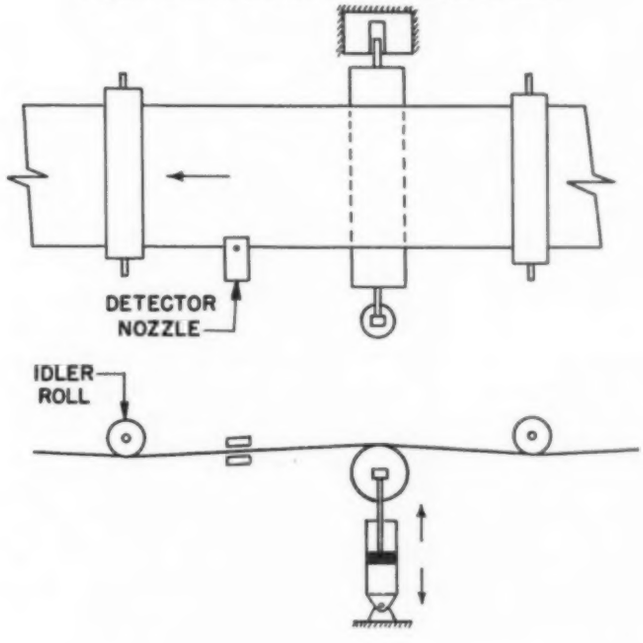


Figure 18 — A turning pivot roll helps guide strip.

Figure 19 — A tilt roll also helps guide strip.



a. On pay-off reel applications the strip edge is positioned with respect to a fixed frame of reference and every possible effort must be made to allow the strip to move laterally.
b. On wind-up reel applications, the reel is positioned to the strip edge and every effort must be made to keep the strip from moving laterally.

Intermediate strip guiding—Edge position controls are generally applied to the pay-off or wind-up reels. However, intermediate guide rolls are often used to guide the strip within a process.

Figure 18 depicts the pivot turning roll and Figure 19 the tilt roll. Both of these methods are successful in guiding the strip within limits. Since they depend on friction of the strip across the roll, there is a time lag between motion of the guide roll and motion of the strip. On slow moving process lines, the turning rolls are satisfactory within limits. However, on high speed lines the results are not entirely satisfactory.

Steering roll method of edge position control—The offset pivot steering roll system illustrated in Figure 19 is a positive and accurate method of guiding the strip at an intermediate point within a process. This system has been used most successfully on paper, paperboard, foil and aluminum, and can be used on any gage strip that permits a 180 degree contact on the steering roll.

The term "steering roll" is a fitting description for this system, since the strip course is altered as it leaves the steering roll and sets over on the next idler roll, but does not change its actual lateral position on the steering roll itself. In this respect, it is different from the pivot turning roll, or tilt roll, which actually causes the strip to take a new lateral position on the rolls themselves to effect a correction.

As illustrated in Figure 20, the displacement of strip edge lateral position is a function of the outside diameter of the steering roll multiplied by the sine of the angle about which it turns. It is suggested that this angle be a maximum of $\pm$ 5 degrees from mid-position. With a maximum of ± 5 degree angle, no appreciable change in tension is noticed, and the strip maintains contact on the turning roll and idler rolls without having a tendency to buckle.

Other edge position applications—In the preceding sections, we have discussed principally methods of positioning the strip to guide it into a process or to wind straight coils on the exit end of the line. Employing automatic edge position control as a follower control, it is possible to position a marking tool or a similar device relative to the strip edge. For example, it is practicable to position a slitter knife housing to the strip edge to maintain an even amount of side trim.

On an application such as described, it is important that the strip be under constant tension and that positioning the slitter does not cause the strip to move laterally. Multiple slitting would not be satisfactory because it is probable that multiple contact points on the strip would cause it to move. This application is similar to that of the wind-up reel in that the detector nozzle is moved to follow the strip weave, and at the same time the strip must be prevented from moving. Otherwise, the control system would never reach a neutral position.

SUMMARY

In this paper the author has endeavored to demonstrate that automatic edge position control can be applied to continuous processing lines in many forms. Each individual application usually warrants a separate discussion, however, there are certain design details that apply to all applications. It was the author's intention to discuss certain details that should be considered in the design of a continuous process line when edge position control is to be applied. Since edge controls are principally applied to the pay-off and wind-up reels, the bulk of this paper is devoted to these applications.

DISCUSSION

PRESENTED BY

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C. C. THOMAS, Steel Mill Engineering, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

CLARK HAGUE, President, Hague Regulator Corp., Orangeville, Ohio

J. B. Brown: The information Mr. Markey has provided is an excellent reference for any engineer faced with the problem of providing suitable guiding facilities on strip processing lines. Our recent experience on the installation of edge guiding units on two winding reels at Thomas Strip Div. may provide additional information that will be of interest.

Owing to the weight of nearly 10 tons of each winder, we decided to use roller bearings rather than sliding ways to allow for traversing. Since rolling friction is quite small, a small cylinder and hydraulic system were selected for installation, but two factors immediately arose which required more cylinder force: (1) side loading between reel and stationary base from the horizontal component of strip tension, and (2) the beam action of a strip under heavy tension. Rollers to replace the guiding shoes alleviated the first problem, but the second was not so easily met. After investigation, it was found that the initial available force of about 1000 lb had to be nearly doubled to permit side movement of the reel when winding strips of 24-in. width and thicknesses of about 0.050 in. This problem becomes particularly pronounced if cambered strip is encountered and large corrections are necessary.

An interesting variation was made for our installations which follow an electrolytic galvanizing line

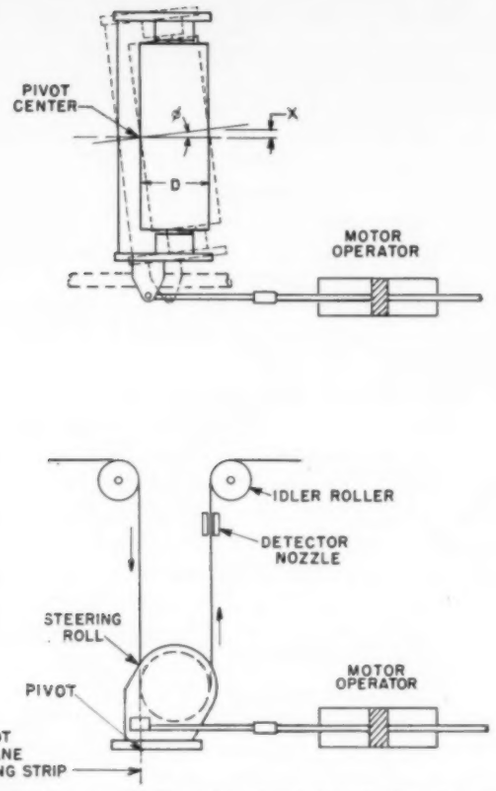

Figure 20 — Displacement of strip edge laterally is a function of the outside diameter of the steering roll and the angle about which it turns.

operating at a speed of about 50 fpm. During the plating process zinc deposits on the edges of the strip sometimes become quite heavy, and a coil wound with perfectly straight sides has all of its tension concentrated in a very narrow band at the edges. This is a highly unstable situation such that the coil may at any time begin sliding sideways and become badly telescoped. To overcome this difficulty, an oscillating mechanism has been incorporated which may be adjusted to provide from zero to nearly ½ in. of side movement. This arrangement consists of a cam with adjustable center position driven through a suitable gear reduction from the winding reel drive motor. Rotation of the cam is changed to lateral motion of the arm carrying the sensing device so that it moves relative to the winding reel and at right angles to the direction of strip travel. Thus an error is steadily introduced on a per lap basis which permits a broad distribution of pressure between coil laps but with no sacrifice of neat coil appearance.

This arrangement is also useful in alleviating the same lap-sliding tendency encountered with crowned center strips.

Frank J. Markey: Mr. Brown's comments are most interesting. His method of moving the sensing nozzle back and forth in a definite pattern will permit each lap of the coil to be staggered ⅛ or ¼ in. This can prevent the edge of the coil from building up as is often the case on galvanized steel.

E. W. Bruns: We have been experimenting with the use of anti-friction roller bearings on our payoffs, with only minor success up to now. I was about to ask Mr. Markey whether he had made any tests on any payoffs so equipped, and what was the coefficient friction under those circumstances?

Frank J. Markey: On installations where the pay-off reel was mounted on anti-friction bearings, we have found the coefficient of static friction to be as low as 0.03. Our experience thus far with anti-friction bearings indicate that they are satisfactory for loads below 10 tons and strip speeds not in excess of 1000 fpm.

One point that must be considered about anti-friction bearings is the force required to stop the moving reel. When we are moving a heavy weight, which can approach as much as 100 tons, we must also consider the inertia involved and remember that it is necessary to decelerate this mass, stop it, and then move it in the opposite direction. The force due to inertia creates an additional time lag in the system, which can produce an unstable system.

In addition, a heavy reel mounted on anti-friction bearings is an expensive item. The maintenance would also be extremely high.

R. H. Laudeman: We have used side edge controls since the late forties; our first installation being on tension reels. Tension reel applications, now commonplace in the industry, do not seem to cause much difficulty for anyone.

The side trimmer installation that Mr. Markey mentioned is at Inland, and I believe it is unique to the steel industry. The use of side edge control in this instance eliminated the need for extensive and expensive relocation of the entry end equipment. It might have been classified as a gamble that paid off.

From other experience we have adopted a policy, when using hydraulic motor operators, of providing separate hydraulic systems for each unit. This is due to difficulty encountered from pressure fluctuation of hydraulic systems which are used jointly with other equipment, such as coil handling devices. I might add that with applications of this type, the length of the air line from the sensing nozzle to the control cabinet must be kept to a minimum.

Also, on hydraulic systems, used on this control, I would like to mention that we have used various types of non-flammable solutions in our low pressure systems—but so far we have been rather unsuccessful in finding a suitable fluid for high pressure applications.

I would like to ask if Mr. Markey has ever found any satisfactory non-flammable hydraulic fluid for, say, 500 to 600 psi or above? I would also like to ask if there are any successful steering roll applications in the steel industry? You seemed to indicate that there were none.

Frank J. Markey: In reply to Mr. Laudeman's question concerning non-flammable fluids, we have for many years used such fluids in low pressure systems. We have not at this time found one of these fluids that will operate successfully without foaming at high pressure. Foaming, of course, in a control system is not tolerable.

In regard to Mr. Laudeman's question concerning a steering roll application, we do not have any operating similar to the one described here on a steel strip line. We do have several operating on aluminum and aluminum foil. There is one operating on aluminum installed ahead of a slitter. The steering roll guides the aluminum into the slitter to a tolerance of plus or minus 1/64 in. This line operates at 250 fpm. I am sorry that we could not have more information available on this project, however, the nature of the process is

secretive and we were unable to obtain any photographs or other data.

Eli Shay: Mr. Markey has done an excellent job of setting forth the important principles and data involved in the proper integration of edge guide control components in a modern processing line.

This information has evolved and accumulated from experience in actual practice, with the cooperation of the control component builder, the user, and the processing line designer and builder. They will undoubtedly be referred to by all in the industry who have the problem of designing edge guide control for high-speed processing lines.

Strip position in a high-speed processing line must be confined within very close limits through a multiplicity of machines to prevent edge damage, to reduce edge damage in subsequent processing, and to ultimately have the product acceptable to the customer.

Automatic edge position control in a processing line is the continuous forcible positioning of a machine, either uncoiling, processing or recoiling, so as to keep the strip within these limits.

The methods of guiding strip in most prevalent use today, as Mr. Markey pointed out, are as follows: 1. mechanical side guides, 2. self-centering or narrow-bodied rolls, 3. On-off positioning control, and 4. continuous proportional control.

In high-speed processing lines, the continuous proportional control method is used predominantly. Two schemes are available: 1. floating electric control (electronic-electric-hydraulic), 2. pneumatic-hydraulic system. Both are doing an acceptable job in correctly designed lines. The processing line design principles discussed in Mr. Markey's paper apply equally well to both methods and must be considered to achieve successful operation with either method.

In 1951 we equipped a 2000-fpm cleaning line with both floating electric control and pneumatic-hydraulic control, for comparison purposes. Either system could be used by merely shutting off or turning on valves in the hydraulic motor operator. After many comparisons, the user reported that either method will perform satisfactorily, but the pneumatic-hydraulic system, once properly adjusted, is more easily maintained.

We recently installed an electrolytic tinning coil preparation line, rated at 4000-fpm, with pneumatic-hydraulic edge control for positioning the coil holder.

This control is doing a very good job of keeping the strip edge within the side trimmer knives. This, of course, is a tight line, held under precisely regulated strip tension.

We have numerous installations of recoilers in cleaning lines, annealing lines, tinning lines and galvanizing lines, using the pneumatic-hydraulic facility for recoiler positioning to wind up finished product, all performing very satisfactorily.

We have one installation of a side trimmer in a tinning line, positioned to follow the edge of the horizontal strip under tension to keep the knives cutting the edge regardless of the inevitable weaving of the strip.

Successful designs of edge-guide-control-equipped processing lines will include the data and principles discussed in Mr. Markey's paper, along with other important regulating techniques involved in high-speed processing line dynamics.

These high-speed processing lines today are producing higher tonnages of better quality product because of the courage and foresight of the steel producer, the component manufacturer, and the equipment builder and coordinator working together in their continual efforts toward greater productivity.

C. C. Thomas: Although the broad principles of edge position control have been known and used for quite some time, this is so far as I know the first time anyone has taken the trouble to document them so completely.

There are two points, not yet covered by Mr. Markey or the previous commenters which should be mentioned.

First, there is the question of penumatic hydraulic controls versus photoelectric rotating regulator type. It must be admitted that for many applications the hydraulic control has the advantage of simplicity and lower cost. It must also be admitted that within reason anything that can be done electrically can be duplicated hydraulically. But it seems to me that there are some modifications which are required on the more difficult or unusual applications that can be more simply made to an electric control.

For example, someone mentioned the problem of regulating the edge position on a wind-up reel, which was coiling strip with edges thicker than the web. To wind a good coil it was necessary to drive a cam which slowly oscillated the edge detector to insure the wraps would not lay on top of each other. With the electric system this has been done by the simple adjustment of a stabilizing resistor brought out to the operator's desk.

Another example is the case where a simple mechanical layout of the line does not permit a close pass line tolerance. Here I believe the photoelectric edge detector has the advantage over the air jet detector because a greater distance can exist between the transmitter and the receiver elements.

And there is also the case where the mechanical layout and the range of operating speeds cause severe "transport lag effects." This effect is common in many systems where the measuring and the correcting is not done at the same place. In other words if it is wished to regulate the edge of a strip feeding into a side trimmer by shifting the position of an uncoiler, some mechanical layouts introduce a time delay (inversely proportional to strip speed) between the shifting of the reel and the actual shifting of the strip under the detector head. If a regulating system of this nature must be stabilized with a single set of adjustments for all strip speeds and tensions, it quite likely will be rather poor in performance. This means low gain (sensitivity), slow response, and poor accuracy, at high speeds and low tensions in order to favor the low speed and high tension condition. In an electric system it is a fairly simple matter to readjust the stabilizing components as a function of speed, tension, or any other variable which may limit the performance.

Second, it is important to mention that even a perfect edge control cannot hold a true edge position on a winding reel if the strip has camber, or curvature between the scanning head and the coil. Of course if the camber were constant and always in the same direction, a perfect coil would result but this obviously does not happen. Many coils will exhibit a slightly wavy shape on the coil ends on account of variations or

reversal of camber. This condition is exaggerated by excessive distance between the detector unit and the coil and likewise can be reduced by making the distance a minimum, but it cannot be eliminated so long as these basic mechanical systems described by Mr. Markey are used.

Frank J. Markey: What Mr. Thomas says is true. Oftentimes on a slow moving process line, such as a galvanized line, there is a considerable time lag between the point of detection and the winding reel. However, the detector, regardless of what type is used, must be located upstream of the last fixed idler roll. It is possible to adjust the control system to operate satisfactorily, although a time lag as great as 10 seconds exists between the detector and the reel.

At this time, I would like to make one comment on what Mr. Shay had to say in regard to other controls on the line. Accurate tension control is required on a high speed process line and the edge control cannot function properly without it. Oftentimes, the edge guiding equipment is criticized when a set-out appears on a winding coil on the tension reel. In most cases, the edge control equipment is not responsible for this error. The set-out is caused by lack of tension during a deceleration period.

Eli Shay: Mr. Brown mentioned using anti-friction systems on machines to reduce friction. We have never had that requirement, never had the need to do that. I am just wondering what created it, the need for reducing friction?

J. B. Brown: The answer is that it was one of economics. I will not quote any prices on Mr. Markey's equipment, but will just say that the weight of this winder was such that the use of anti-friction bearings allowed us to use one of the smallest units they manufacture. As a result, the higher cost of rollers over sliding shoes was more than offset by the savings in the purchase cost of the edge control unit.

Eli Shay: From our point of view, the cost of edge guide regulating equipment for shifting total weights of coil and machine of 120,000 lb as a part of the overall cost of the reel or uncoiler is relatively insignificant. This, of course, may not be the case as the size of the reel or uncoiler becomes smaller and lighter in weight.

J. B. Brown: Our coil weight is 20,000 lb.

Eli Shay: When you get to handling equipment for 120,000 lb, then the economics of a system like this becomes negative.

J. B. Brown: We were at the breaking point, I think. Over that weight, probably your statement would be quite correct.

Clark Hague: If I were to emphasize any one point he made, it would be concerning the matter of time lag in the length of signal line between the detector nozzle and the regulator, itself. There is a bit of a time lag, that is transmission time lag there, and I think that the author has found, as we have found, that keeping those signal lines very short pays off handsomely in operating stability.

Frank J. Markey: What Mr. Hague says is true. The length of the signal line is an important factor to consider for a stable system and is particularly important on high speed lines. We have made frequency response tests on this system and find that we have an inherent time lag of something slightly less than 0.1 sec. This is due to the compressibility of the air in the signal line length, there is no change in this lag. On signal lines above 10 ft, a lag is introduced in the system which on high speed lines can result in an unstable control. Fortunately, on most process lines and particularly on those that are designed for edge guiding, the regulator can be located within 10 ft of the detector.

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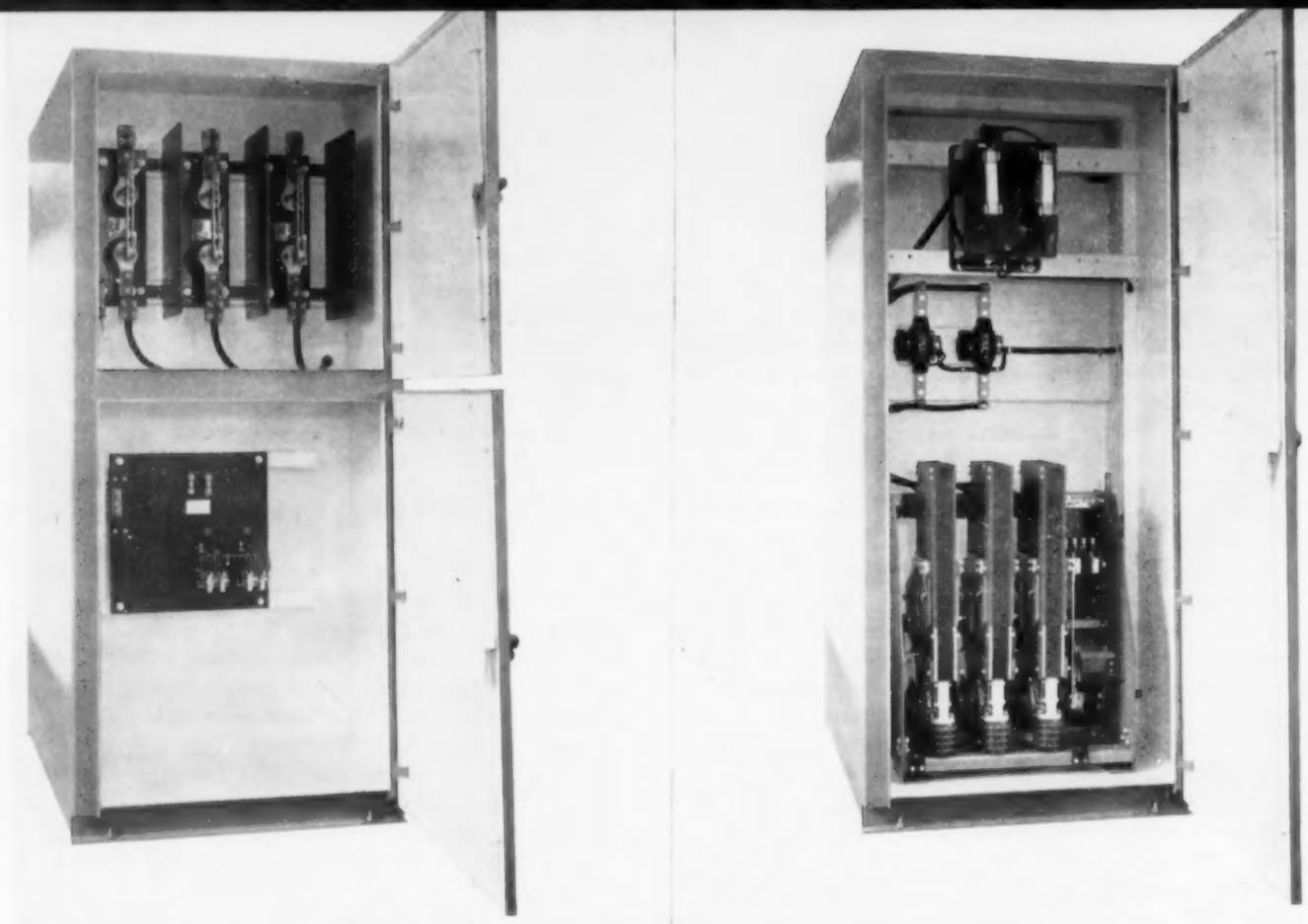


Figure 1 — Air-break motor starter for 200-hp, 2300-volt induction motor having an interrupting rating of 50,000 kva is a typical unit.

High interrupting capacity controllers for 2300-4600 volt motors

By CHARLES A. LISTER, Assistant Supervisor,

Development Engineering, Electric Controller & Manufacturing Div., Square D Co., Cleveland, Ohio

NOT many years ago, a-c motor controllers had interrupting ratings of ten times full load motor current, which was adequate for handling running currents and locked-rotor currents, but commonly too small for fault interruption. Reliance was placed on circuit breakers ahead of the controllers for interrupting short-circuits, and no guarantee was made on what might happen to the controller during the period required by the breaker to open the circuit. During the past two decades, there has been an increasing demand for controllers with high-interrupting capacity, and today practically all controllers for 2300 to 4600-volt motors are of the high-interrupting capacity type. These controllers, in addition to performing the regular functions of starting, stopping, reversing, plugging, jogging, and dynamic braking, also include means for interrupting short-circuit currents, and are built to withstand the thermal and electromagnetic effects of short-circuits during the time required for interruption.

Depending upon means used for limiting and interrupting short-circuit currents, high-interrupting capacity controllers may be classified as follows:

1. Controllers in which the line contactor is used for interrupting short-circuits and in which no fault limiting means is provided.

. . . . air-break and oil-immersed motor controllers are now available with high-interrupting capacity . . . . these have been tested in service and short-circuit tests . . . . controllers take many different forms depending on the application but all have the ability to do their job . . . .

2. Controllers which employ fuses for interrupting short-circuits.
3. Controllers in which the contactor interrupts short-circuits but which include air-core reactors for limiting the magnitude of the short-circuits.

Under NEMA Standards[1],* controllers which employ the contactor for interrupting short-circuits may be used in circuit locations where the available symmetrical fault kva from all sources does not exceed 50,000 kva at the incoming terminals of the controller. Fused starters, covered by NEMA Standards, may be used where the available symmetrical fault kva is as high as 150,000 kva on 2300-volt systems and 250,000 kva on 4600-volt systems. Controllers with air-core reactors for limiting fault currents are not included in NEMA Standards, but can be built for use on systems of any available short-circuit kva. In these starters, the reactors limit the current to a value lower than the interrupting rating of the contactor in the controller. All three forms of starters can be built using either air-break, or oil-immersed contactors. The rating of controllers in terms of *symmetrical* kva was adopted to make application simple since with this method of rating, it is not necessary to calculate the magnitude of d-c components present during faults. The controller must be able to interrupt the circuit regardless of the magnitude of any d-c components present, and the standards for testing are written accordingly.

STARTER WITH 50,000 KVA INTERRUPTING RATING CONTACTOR

Figure 1 shows a typical motor starter employing a contactor designed to interrupt fault currents where the available symmetrical fault kva does not exceed 50,000 kva. This is an air-break starter for a 200-hp, 2300-volt, 3-phase, squirrel cage induction motor. In the upper front compartment, separated by steel barriers from the other compartments, are disconnect switches and a door switch for de-energizing the contactor magnet when the door to the disconnect switch compartment is opened. Directly below is a compartment housing overload relays and other low voltage devices. For synchronous motor controllers, the field switch and synchronizing equipment are located here. The low-voltage panel is supported by hinged brackets so that the assembly can be swung out for servicing

*Numbers in parentheses refer to Bibliography at end of paper.

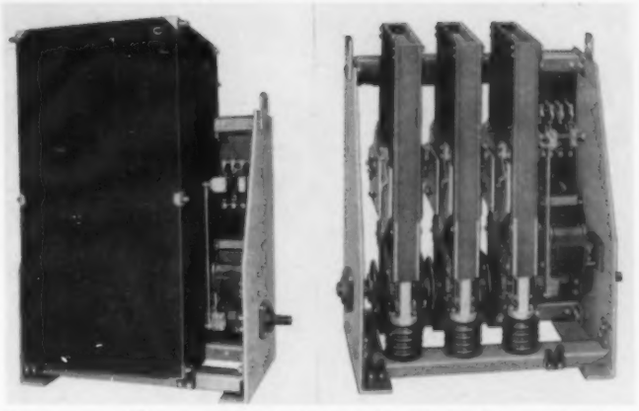


Figure 2 — The contactor is the heart of the controller. One shown is rated 200 amp, 2300-4600 volt, 50,000 kva.

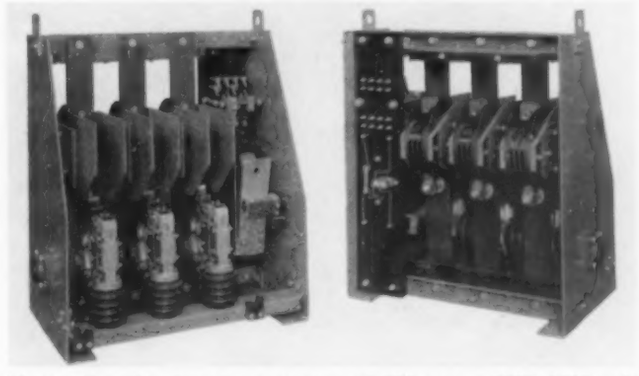


Figure 3 — Air-break contactor of 400-amp, 2300-4600 volt capacity, is shown with phase barrier assembly and arc chutes removed.

and for access to the contactor located behind a removable steel partition. Any meters required are placed on the door of the low-voltage section, as are push buttons and indicating lights.

A fused control power transformer is located near the top of the rear high-voltage compartment, and when potential tranformers are required for metering, they are located adjacent. Current transformers are located beneath the control power transformer, and an air-break contactor is mounted at the bottom of the compartment. (For the photograph, a barrier assembly which provides phase to phase insulation between the poles of the contactor, was omitted.) Space has been provided for mounting two potheads between the contactor and the rear of the low-voltage compartment.

AIR-BREAK CONTACTOR

The heart of the controller is, of course, the contactor—in this case a 200-amp air-break contactor having 50,000 kva interrupting rating. The left hand portion of Figure 2 shows this contactor complete with phase barrier assembly. This barrier, which is closed front and top but open at the rear to vent gases, is removed by lifting slightly and drawing out. When this is done, the contactor appears as shown in the right-hand view. Arc chutes, in which circuit interruption takes place, are supported on laminated high-silicon steel blowout ears, part of a magnetic circuit providing flux across the arc chutes to drive arcs upward. Withdrawal of the arc chutes is horizontal and may be done after the clamps are released.

Figure 3 shows the front and rear views of a 400-amp

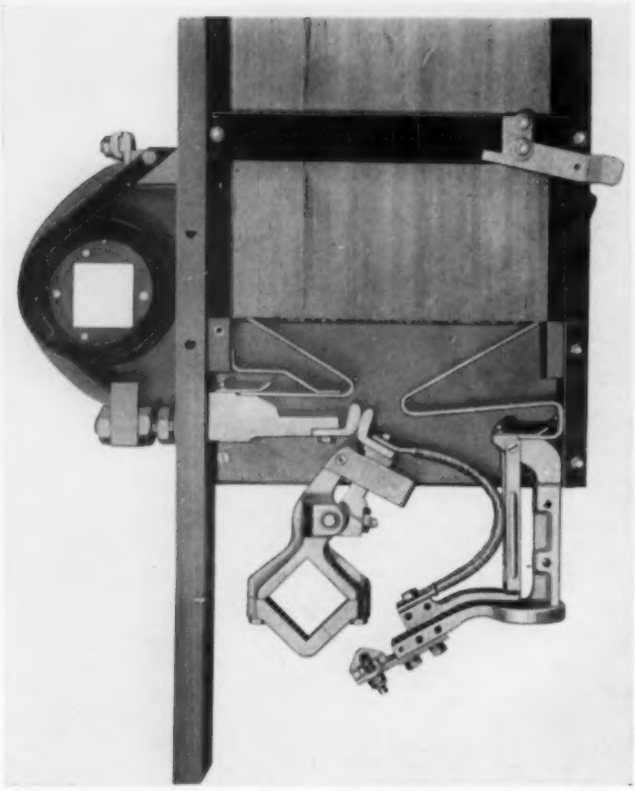


Figure 4 — Cutaway view shows current paths through the contactor.

contactor with phase barrier and arc chutes removed. When the barriers and arc chutes are off, the contact tips and other moving parts are clearly visible for inspection and readily accessible for replacement, a particularly desirable feature because contactors are normally serviced in place. As indicated by the figure, the moving parts are simple, rugged, and generally similar to parts of heavy duty low-voltage contactors used in crane and mill service. Life tests have shown the moving parts to be useful for over two million operations with the exception, of course, of the contact tips whose life depends upon the load handled. Closing of the contactor of Figure 3 is accomplished by a d-c operating magnet while the contactor of Figure 2 is closed by an a-c operating magnet, the magnets being interchangeable.

When a contactor interrupts short-circuits, the high electro-magnetic forces accelerate the moving parts and might cause the contactor to rebound from the open position and re-establish the circuit. This is avoided by use of a special anti-rebound stop which absorbs the kinetic energy of the moving parts. As the armature strikes the stop block, the block rotates and rubs against the armature. By the time the armature reaches the flat of the block, much of the energy is absorbed and no perceptible rebound occurs.

Control circuit contacts are located in an accessible position above the operating magnet, and as many as four normally-open and four normally-closed contacts can be supplied.

Figure 4 is a cutaway side view of one pole showing the current paths through the contactor. Current first passes through a permanently connected blowout coil to excite the blowout structure (not shown), then through the contact tips, a flexible connector and

Figure 5 — Cooling plates are made of glass-bonded mica.

an "anti-blowoff" assembly to the outgoing terminal. The "anti-blowoff" conductors are designed to neutralize the magnetic forces on the flexible connector which would otherwise cause the contact tips to blow apart during short-circuit. When the contactor opens, the arc drawn between the tips is driven by the blowout field onto and up arc runners which guide the arc into the cooling plates stack. Here the arc is forced to take a sinuous path, and the lengthening and cooling of the arc causes it to be deionized and extinguished. Figure 5 shows the cooling plate stack. The plates are made of glass bonded mica, a highly effective material for arc interruption, and one which does not absorb water, and therefore, retains its dielectric strength indefinitely.

In addition to the usual ratings and the interrupting rating, the contactor has an impulse rating of 60,000 volts phase to phase and phase to ground. This means the contactor will withstand positive and negative voltage impulses of 60,000 volts between any two terminals and between any terminal and the frame.

THERMAL AND MAGNETIC OVERLOAD RELAYS

Protection against operation under abnormal conditions which would damage the motor is afforded by relays. Plain thermal overload relays, which sense motor temperature and initiate disconnection of the motor when safe operating temperature is exceeded, would give protection against locked rotor, low-voltage conditions, and overloading, but these relays are inherently slow and do not trip as fast as desired to minimize damage when short-circuits occur. Consequently, additional relays with fast operation at high currents are needed for fault protection.

In the controller shown in Figure 1, dual purpose relays are provided. These have a thermal section for motor overload protection and an instantaneous magnetic section for tripping upon short-circuit. Figure 6 shows this relay. The rear coil is a primary coil connected to a current transformer in one of the high-voltage lines. The secondary coil is magnetically coupled to the primary coil by a laminated steel core

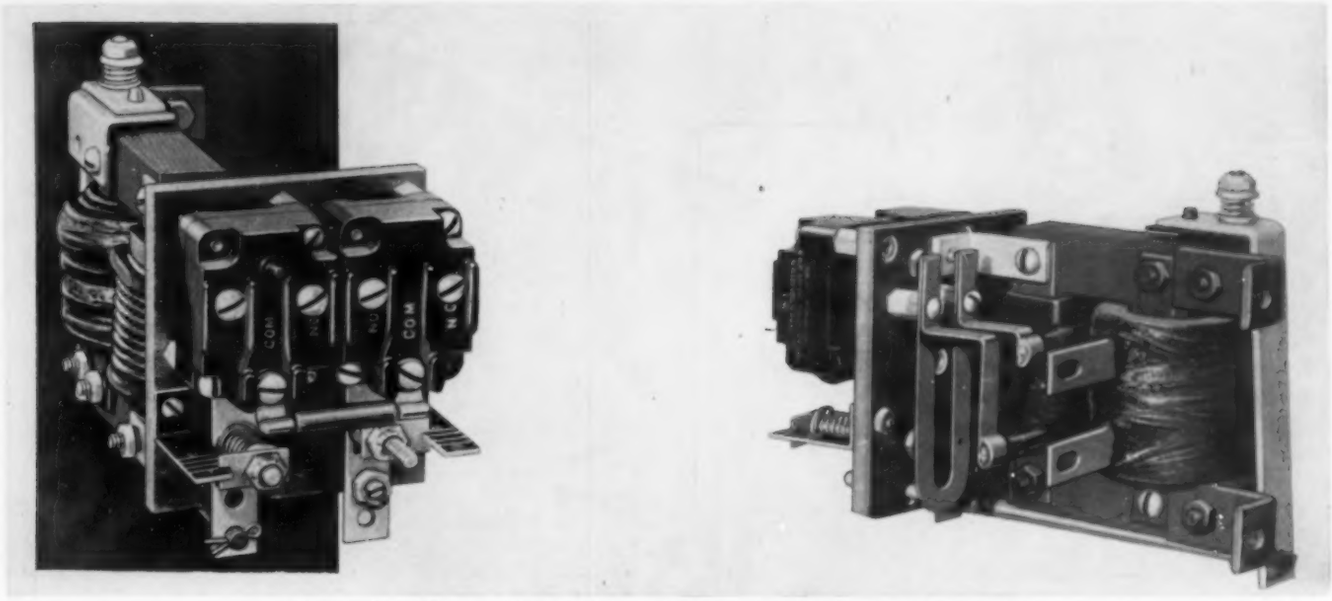
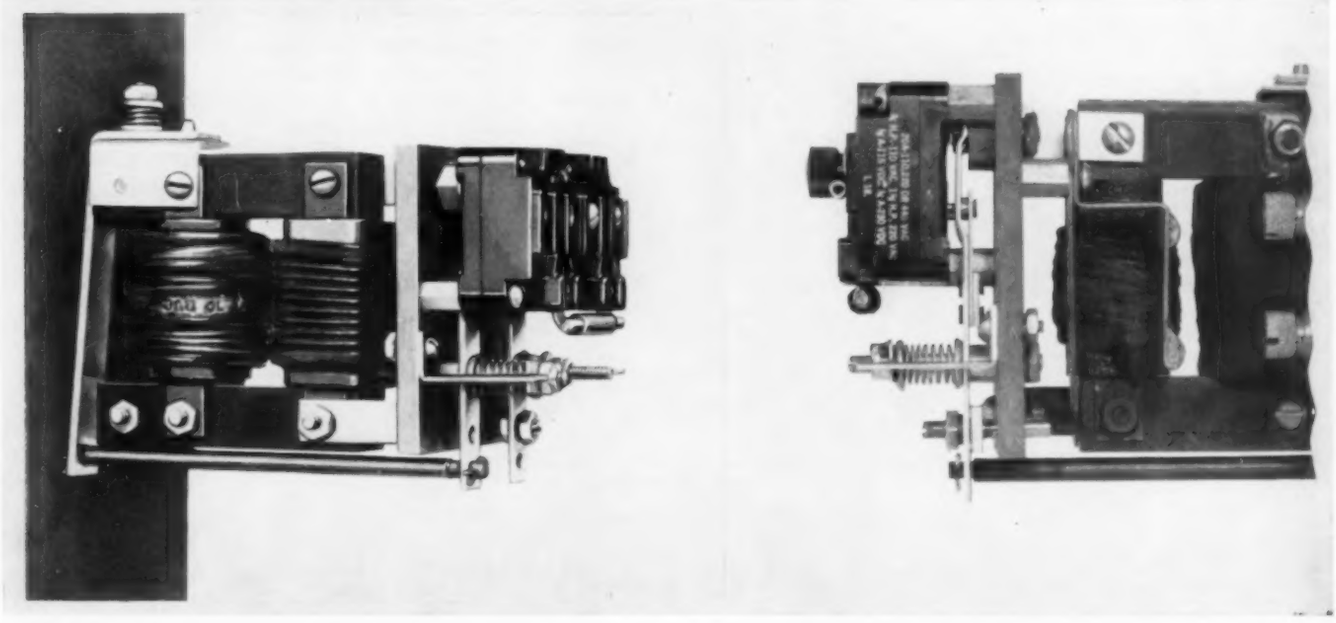


Figure 6 — Front and side views of thermal-magnetic overload relay.

and is connected directly and permanently to a U-shaped bimetal element located just behind the contact switch base, as shown in the right hand view. Two industrial type precision snap-switches are mounted on the switch base, the left hand switch being used for instantaneous magnetic trip, and the right hand switch being used for a thermal trip. The thermal trip lever, on the right, is spring-loaded and is suspended in such a way as to trip the thermal snap-switch when the bimetal strip has deflected a sufficient amount. Means are provided for calibrating and setting the relay to trip at an appropriate percentage of motor full load current and to permit adjusting the current setting easily in the field. The thermal switch is usually furnished with automatic reset, but it can be furnished with hand reset or magnetic reset.

The thermal section of the relay can be set to trip on any value of sustained overload in the range of 110 to 125 per cent of motor full load current; relays protecting 40 C rise motors are commonly set to trip at 125 per cent current, and relays protecting 55 C rise motors are normally set to trip at 110 per cent current. To prevent unnecessary tripping on starting, relatively long trip times at motor inrush currents are provided. This feature was obtained by selecting the size of the magnetic core to give saturation slightly above the excitation caused by a full load current, thus causing the current to the bimetal to be less than proportional to line current during motor starting. For currents of fault magnitude which might destroy other thermal relays, the relay core is highly saturated and current to the bimetal is much less than proportional to primary current, and thus the secondary coil and bimetal are protected from damage. For some applications it is desirable to have tripping of the thermal section independent of ambient temperature and caused

Figure 7 — Left hand view shows instantaneous magnetic trip section and right hand view shows special trip lever for ambient temperature compensation.



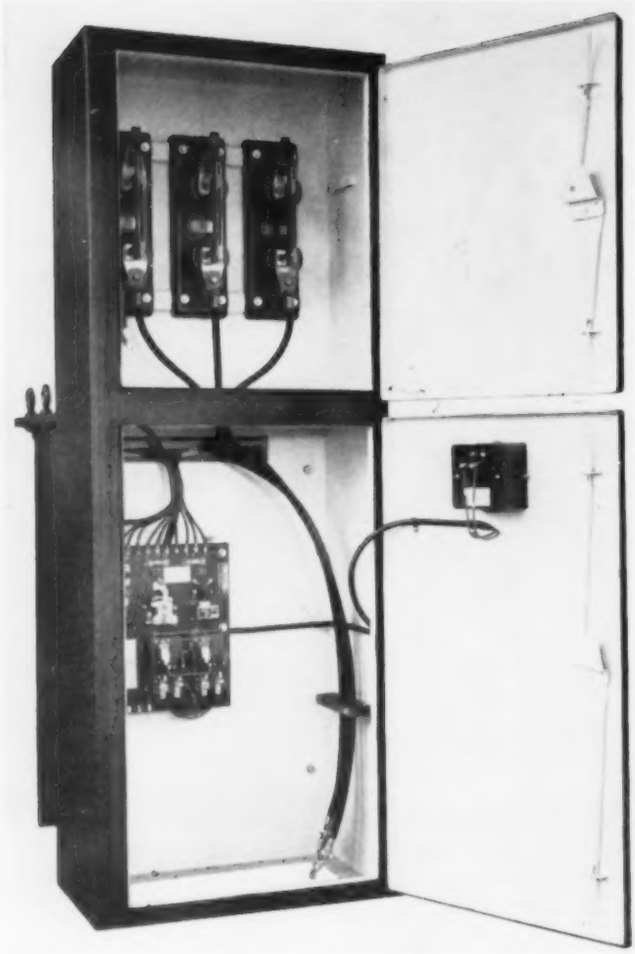


Figure 8 — This controller uses an oil-immersed contactor.

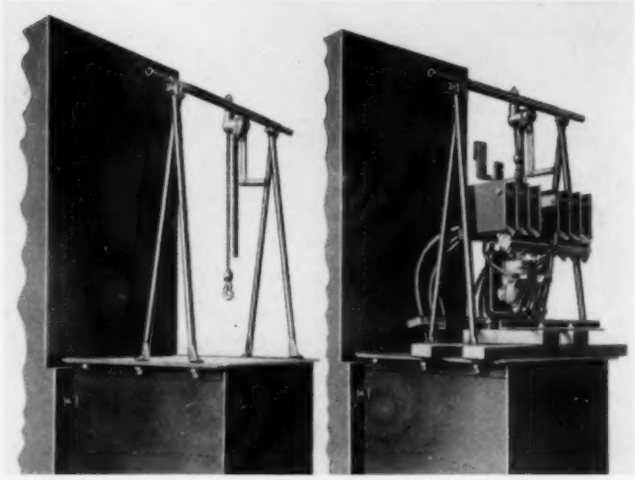


Figure 9 — The contactor can be lifted out of the oil without disconnecting the leads.

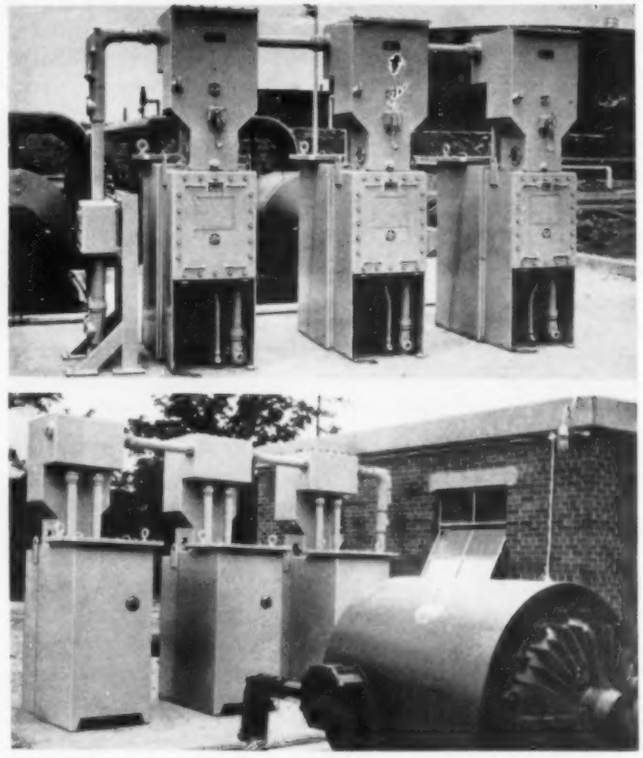


Figure 10 — Controllers in hazardous atmospheres use heavier enclosure construction.

only by sustained over current. For these cases, ambient compensation is provided on the relay and is accomplished by substituting a special trip lever on the thermal section as shown in the right hand view of Figure 7. The special trip lever mounts a bimetal part which compensates for deflections of the main bimetal caused by ambient temperature. Equipped with this special lever, the relay operation is nearly independent of ambient temperature.

The instantaneous trip parts are seen more clearly in the left hand view of Figure 7. The magnetic core has projections to the rear of the primary coil, and a light steel armature, mounted on the upper projecting leg, is positioned by a spring so that an air gap is formed between the armature and lower projecting core leg. This armature is actuated by leakage flux which passes through the armature and across the air gap. The armature is connected by a rod to a trip lever suspended in the same way as the thermal trip lever and arranged to operate the instantaneous section snap-switch. This trip lever is also restrained by a spring which has a compression adjustment to permit setting the relay to trip at the desired current value. The snap-switch of this section of the relay is usually furnished with hand reset since users ordinarily wish to check carefully before attempting to restart a motor after currents of fault magnitude have occurred.

The magnetic section of the relay can be adjusted so the minimum trip current is as low as 12 times motor full load and as high as 25 times full load. This setting is made by adjusting spring compression and is independent of the adjustment on the thermal portion of the relay. For currents of fault magnitude, the magnetic section operates in less than 1 cycle.

OTHER STARTING COMPONENTS

All high-voltage starter components such as disconnect switches, control transformers, current transformers, potential transformers, and cable have a high impulse rating of 45 kv for 2300-volt starters and 60 kv for 4600-volt starters. Those components which carry power current also have high thermal rating to withstand the effects of short-circuit during the period required for interruption. Thus, the starter as a whole is suitable under normal conditions, under conditions of short-circuit, and during voltage disturbances.

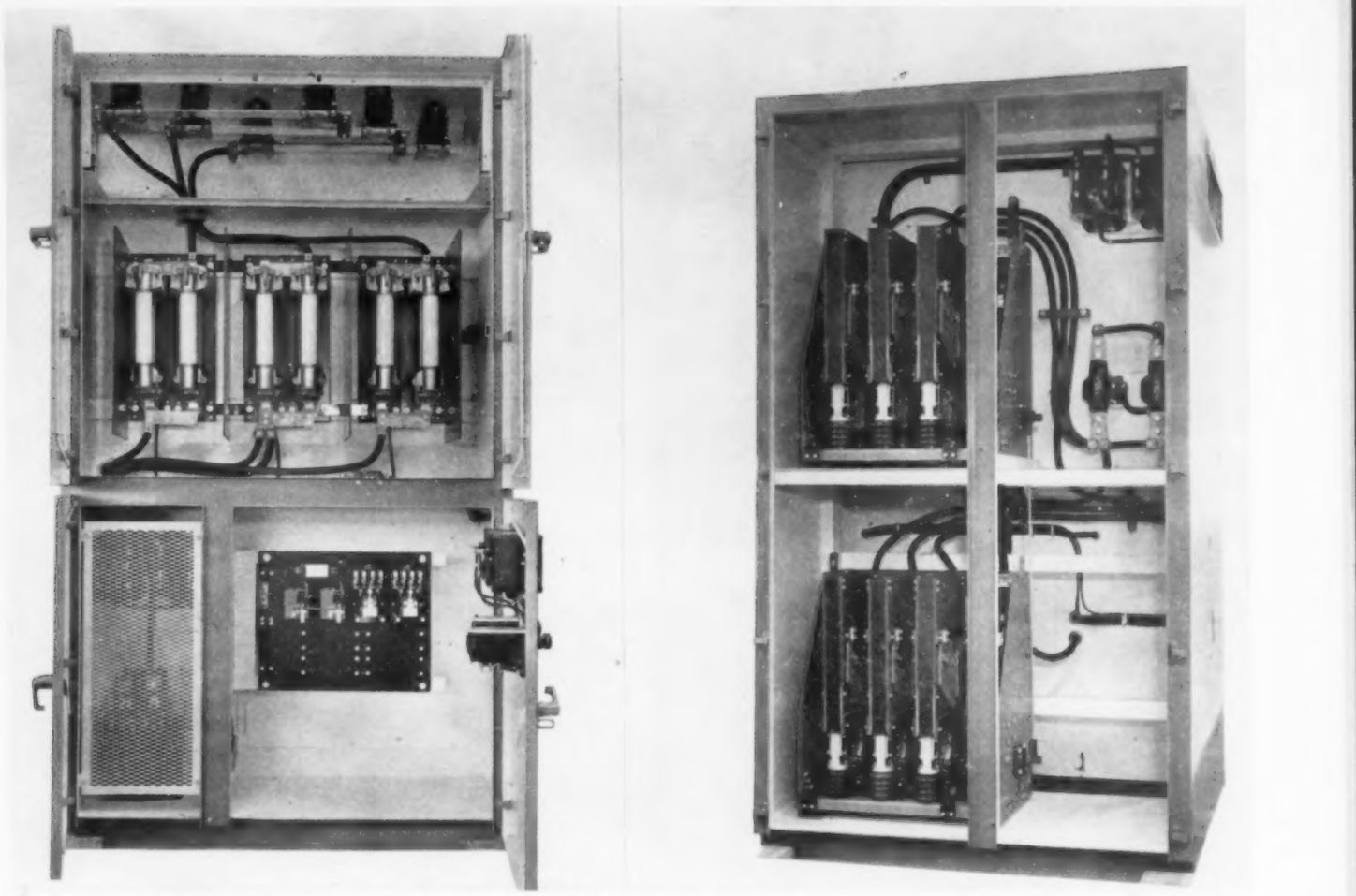


Figure 11 — Air-break reversing and plugging controller shown is used on a 1500-hp, 2300-volt, wound-rotor induction motor driving a rolling mill.

OIL-IMMERSED CONTROLLERS VS AIR-BREAK CONTROLLERS

Figure 8 shows a controller similar in function to the one discussed previously, but employing an oil-immersed contactor. Disconnect switches and a door switch are housed in the upper front compartment and low-voltage devices are housed in the lower front compartment. The contactor together with the control power transformer, its fuses, and the current transformers are located under oil in the tank behind the cabinet. As shown in Figure 9, the contactor can be lifted out of the oil without disconnecting the leads.

Contactors located beneath oil are well protected from the atmosphere, and arcing which occurs during circuit opening is confined beneath the oil. Therefore, oil-immersed controllers are particularly appropriate for use in corrosive and hazardous atmospheres.

Controllers for use in hazardous atmospheres are characterized by heavier enclosure construction as shown in Figure 10. The starters shown are for 500-hp, 2300-volt motors installed in an oil refinery. The upper portion of each starter contains an oil-immersed disconnect switch housed in a steel plate enclosure. The low-voltage compartment, beneath, contains overload relays, and the tank in the rear contains the contactor, control transformer, and current transformers.

Air-break starters offer easy accessibility for inspection and maintenance and give longer contact tip life. They are very well suited for jobs such as coal unloaders, which require repetitive starting, stopping, and jogging. Also, air-break contactors are faster operating mechanically, and therefore are preferred for jobs requiring fast dynamic braking or plugging, such as rubber mills. For a great many applications, oil-immersed or air-break starters are about equally appropriate.

HIGH-INTERRUPTING CAPACITY CONTROLLERS EMPLOYING FUSES FOR INTERRUPTING SHORT-CIRCUITS

Figure 11 shows the primary control equipment for a 1500-hp, 2300-volt, wound-rotor induction motor driving a rolling mill. A bus compartment is provided in the upper front section of the controller, the bus being arranged for connection to similar bus in adjacent starters. The bus is enclosed in its own compartment, the cover of which has been removed for the picture. The power fuses are mounted in clips, the lower of which is hinged so that the fuses also serve as disconnecting means. The door interlock, and low-voltage panel and meters are provided as in the simpler starters. The left hand lower portion of the controller houses potential relays for metering, and the control power transformer. In the rear of the cabinet are reversing contactors, current transformers, and potential transformers for potential interlocking. These

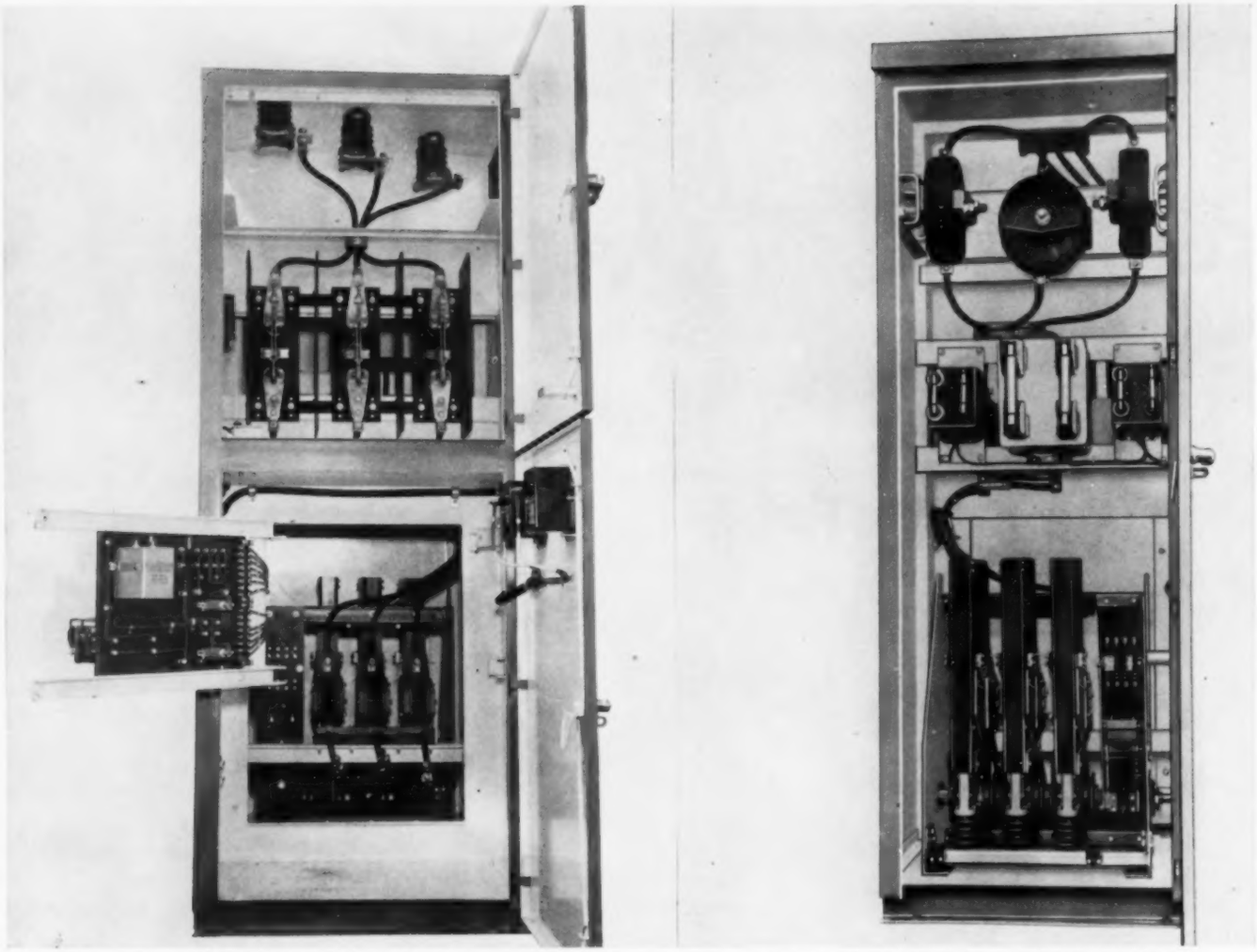


Figure 12 — This 300-hp, 2300-volt, air-break starter has air-core reactors to limit fault kva to less than 25,000.

latter transformers, in conjunction with voltage relays, prevent closing the reversing contactor until the arcs on the other contactor have been extinguished. The contactors are also electrically and mechanically interlocked.

CONTROLLERS EMPLOYING AIR-CORE REACTORS AS CURRENT LIMITERS

A typical controller, having air-core reactors for limiting fault currents, is shown in Figure 12. This particular controller is for a 300-hp, 2300-volt motor, and the impedance of the reactors is of sufficient magnitude to limit the fault kva to 25,000 kva when the incoming terminals of the controller are connected to a bus of infinite capacity. Since, in practice, the impedance of the system ahead of the controller causes the available fault kva beyond the reactors to be less than 25,000 kva, and a contactor with 50,000-kva interrupting capacity is used, a considerable safety factor is provided.

For a given voltage, the reactance of the air-core reactors is determined only by the amount the available kva is to be limited and does not depend upon motor size. However, the current carrying capacity of the reactor must increase with motor size and consequently also, weight and size of the reactors. This imposes a practical limit to the size of motors for which air-core reactor starters are economical. This limit is about 600 hp for 60-cycle motors. The reactors also reduce motor starting currents, the effect being more pronounced with larger motors. For many applications, this is desirable because it gives an effect of reduced voltage starting without the addition of an extra contactor and transfer relay. However, this reduction in motor starting current reduces torque, and care must be exercised in the use of air-core reactors for applications of large motors requiring high starting torques.

SHORT-CIRCUIT TESTS OF AIR AND OIL BREAK STARTERS

In 1953, a series of short-circuit tests were made on high-interrupting capacity controllers at the Crompton-Parkinson Laboratory in Chelmsford, England. These tests were made according to NEMA test specifications for controllers for use where the available symmetrical short-circuit kva is as high as 50,000 kva and in which the contactor is used for starting and stopping the motor and also for interrupting short-circuits. In test, a controller is first short-circuited at its incoming terminals and a test circuit is set up which will produce currents corresponding to the short-circuit kva rating of the controller. The circuit is closed by a switch, and currents, voltages, and other pertinent data are recorded by oscillograph. Following

this, the short-circuit is removed from the incoming terminals of the controller and is placed at the motor terminals of the controller. The circuit is then closed by the contactor and interrupted by the contactor as soon as the instantaneous overload relays of the controller operate. Three of these close-open operations are made at two minute intervals. At the end of the test, the controller must withstand rated voltage when the contactor is open and must be capable of carrying rated current with the contactor closed, but not necessarily without exceeding its temperature rating.

A 200-amp air-break starter was tested at 2300 volts with 50,000 kva and 60,000 kva available, at 4600 volts with 50,000 kva available and at 5000 volts with 60,000 kva available. In each case, the three close-open operations specified by NEMA were made. At the end of the tests, all of which were made with the same contactor, the starter was in usable condition. The tests at 60,000 kva were, of course, greater than required by the NEMA specifications, but were made to prove a comfortable margin above the requirements. No tests were made above 60,000 kva, as there appeared to be no object in proving greater interrupting ability.

Three oil-immersed starters were tested, a 200-amp, 2300-volt starter, a 200-amp, 4600-volt starter, and a 400-amp, 2300-volt starter. These starters were al tested with available fault capacities of 50,000 kva or more and no cases of failure occurred. Reports attesting to the fact that the controllers met the NEMA Standards have been issued by the testing laboratory.

Thus, both air-break and oil-immersed motor controllers of high-interrupting capacity are now available which have been tested in service and in short-circuit tests. Depending upon the application, these controllers take many different forms, but they have in common the ability to do the regular duties well and to stand up under the severe abnormal conditions of short-circuit.

BIBLIOGRAPHY

1. *"Standards for Industrial Control,"* National Electrical Manufacturers Association, New York, N. Y., May 1954, Part 24, pp 1–3.
2. *"Interruption Tests on High-Voltage Air-Break Starter,"* by C. A. Lister, AIEE Trans. Paper 56–31.
3. *"New Thermal Overload Relay with Instantaneous Magnetic Trip on Faults,"* by W. L. Smith and C. A. Lister, AIEE Conference Paper CP56-280.
4. *"Air-Core Reactors as Fault Limiting Means on High-Interrupting Capacity Controllers,"* by John D. Leitch, AIEE Trans. Vol. 68, 1949, pp 469–474. (Reprint No. T9-117 gives more complete data.).

Steelmakers Discuss Use of Materials in Arc Furnaces

On the basis of experience in Sweden, "the production of sponge iron in large quantities for commercial steelmaking seems worth considering," John Stalhed, General Manager of the Sponge Iron Division of Stora Kopparberg Corp., Soderfors, Sweden, advised the 14th Annual Electric Furnace Steel Conference. The conference is sponsored by the Electric Furnace Steel Committee of the Iron and Steel Division of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

The speaker pointed out that Sweden's steel production is to a great extent specialized on high-grade steel and that of the total steel production (about 2,500,000 metric tons in 1955) some 550,000 tons were high grade steel. The greater part of this quantity, is produced in electric arc furnaces. He reported that sponge iron fulfills the requirement of a suitable carbon content as well as a high purity and has proved to be an excellent raw material for the electric furnace. Melting time usually is somewhat increased when using sponge iron but, at the same time, the refining period can be made shorter. Therefore, the total time may be the same or even shorter for a charge consisting mostly of sponge than for a 100 per cent scrap charge.

The total cost of melting sponge in the electric furnace is not higher than for melting scrap, provided that a suitable procedure is used. So far, sponge iron is used in Sweden only for high-grade steel. However, in spite of the fact that it is produced only in small quantities, production cost is not higher than for pig iron. Sponge iron offers the possibility of replacing coke as a reduction medium with either natural gas or oil.

In a paper discussing the benefits of the use of virgin melting stocks, P. E. Cavanagh, of Toronto, Director of the Department of Engineering and Metallurgy, Ontario Research Foundation, said:

"In many studies of the use of virgin melting stocks in electric steelmaking, conclusions are based on the cost of the melting stock as it enters the steelmaking furnace. The true comparison must be in the actual increase in profits obtained from the operations of the company as a result of introducing virgin melting stocks as part of the charge.

"The additional profit will arise out of possible savings in the cost of furnace operations, in lower operating costs in further processing, rolling, forging and annealing of the product, and in the improved customer relations and lowered percentage of rejected material arising from a known and uniform quality in the steel.

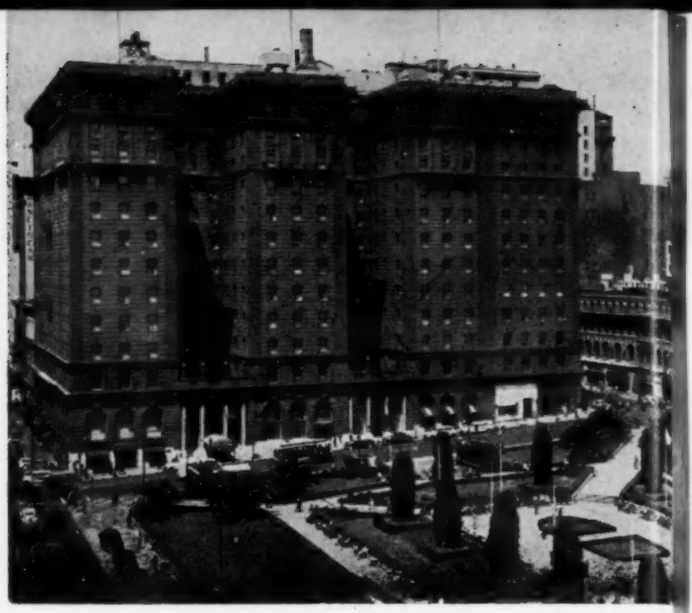
"All steelmakers know that a large proportion of their problems would be solved by reducing the residual content of their steel ingots to half the present levels and maintaining them at a known level. This desirable end can be achieved by the use of virgin melting stocks."

PROGRAM

AISE Western Meeting

ST. FRANCIS HOTEL
SAN FRANCISCO, CALIFORNIA

March 4, 5, 6, 1957



MONDAY, MARCH 4

8:30 am—REGISTRATION

9:00 am—TECHNICAL SESSION—Colonial Room

Chairmen: W. T. Purvance, Works Engineer, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

G. W. Teskey, Jr., Superintendent Open Hearth, Bethlehem Pacific Coast Steel Corp., San Francisco, Calif.

"Basic Hot Blast Cupola as Source of Hot Metal for Steel Plants," by E. S. Harman, President, E. S. Harman Corp., Chicago, Ill., and Siegfred Tunder, Vice President and General Manager of Technical Operations, GHW (Gesellschaft fur Huttenwerksanlagen, m.b.H.) Dusseldorf, Germany

"The All-Basic Open Hearth Furnace," by R. P. Heuer, Vice President, and M. A. Fay, Assistant General Sales Manager, General Refractories Co., Philadelphia, Pa.

"Economics of Oxygen Generating Stations for Steel Mill High and Low Purity Oxygen Applications," by Arthur E. Steele, Assistant to General Sales Manager, and Donald E. Cummings, Manager, Steel Mill Sales Division, Air Products, Inc., Allentown, Pa.

2:00 pm—TECHNICAL SESSION—Colonial Room

Chairmen: E. C. Thomas, Works Manager, Pacific States Steel Corp., Niles, Calif.

R. J. Tremblay, General Manager, Bethlehem Pacific Coast Steel Corp., Los Angeles, Calif.

"Industries' Water Problems and Their Solution," by H. I. Riegel, Superintendent Utilities Dept., Kaiser Steel Corp., Fontana, Calif.

"Mill Gearing as Viewed by a Lubrication Engineer," by A. E. Cichelli, Lubrication Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

"Selection and Economy of Equipment for Blooming and Slabbing Mills," by Kurt Schlesinger, Project and Sales Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

"Recent Developments in Slabbing Mills," by H. J. Kalberkamp, Chief Engineer, Mesta Machine Co., Pittsburgh, Pa.

TUESDAY, MARCH 5

9:00 am—TECHNICAL SESSION—Colonial Room

Chairmen: William Brill, Director of Engineering, The Colorado Fuel & Iron Corp., Pueblo, Colo.

W. F. Pruden, Chief Engineer, Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif.

"The Facility Round-Out Program at Columbia-Geneva," by Harold G. Degitz, Staff Engineer, Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif.

"Coordination between Engineering and Other Departments," by J. William DePoy, Chief Engineer, Pacific Coast Div., The Colorado Fuel and Iron Corp., Oakland, Calif.

"Silicone Lubricants and Protective Coatings in the Steel Industry"
Part I—**"Silicone Lubricants,"** by W. H. Ragborg, Laboratory Supervisor, and W. H. Badger, Development Engineer, Fluids Section, Product Development Laboratories, Dow Corning Corp., Midland, Mich.

Part II—**"Silicone Protective Coatings,"** by R. C. Hedlund, Supervisor, Coatings Laboratory, Product Development Laboratories, Dow Corning Corp., Midland, Mich.

2:00 pm—TECHNICAL SESSION—Colonial Room

Chairmen: C. C. Brandt, Superintendent, Electrical Department, Bethlehem Pacific Coast Steel Corp., Los Angeles, Calif.

E. F. Donatic, General Superintendent, Kaiser Steel Corp., Fontana, Calif.

"Greater Flexibility for Wire Drawing," by R. C. Suttle, Application Engineer, Reliance Electric & Engineering Co., Cleveland, Ohio, and Maurice A. Nye, Chief Engineer, Vaughn Machinery Co., Cuyahoga Falls, Ohio

"Methods of Control of Strip Thickness on Hot Strip Finishing Mills," by R. A. Phillips, Control Systems, Analytical Engineering Section, General Electric Co., Schenectady, N. Y.

"Steel Mill System Studies," by D. Dalasta, General Engineer, and F. Nolan, Application Engineer, Switchgear Department, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

"The Application of Static Switching to the Steel Industry," by D. Lawrence Pierce, Assistant Manager, Control Dept., Motor & Control Div., Westinghouse Electric Corp., Buffalo, N. Y.

W. T. PURVANCE

G. W. TESKEY, JR.

E. C. THOMAS

7:00 pm—INFORMAL STAG DINNER—
Colonial Room

WEDNESDAY, MARCH 6

Inspection Trip to South San Francisco Plant, Bethlehem Pacific Coast Steel Corp., San Francisco, Calif. Buses will leave the St. Francis Hotel at 8:30 am.

hotel reservations

Write direct for hotel reservations to St. Francis Hotel, Union Square, San Francisco 19, Calif., giving time of arrival and type of accommodation desired. Reservations should state that they are for AISE Western meeting.

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transportation

Individuals or groups desiring assistance in planning their trip should get in touch with the office of American Express Co., in their respective cities or with any local travel agency.

R. J. TREMBLAY

WILLIAM BRILL

W. T. PRUDEN

C. C. BRANDT

E. F. DONATIC

Abstracts of Technical Papers

to be presented at

AISE WESTERN MEETING

March 4, 5, 6, 1957

ST. FRANCIS HOTEL SAN FRANCISCO, CALIF.

"BASIC HOT BLAST CUPOLA AS SOURCE OF HOT METAL FOR STEEL PLANTS"

by E. S. HARMAN, President, E. S. Harman Corp., Chicago, Ill., and SIEGFRED TUNDER, Vice President and General Manager of Technical Operations, GHW (Gesellschaft für Huttenwerksanlagen, m.b.H.) Düsseldorf, Germany.

E. S. HARMAN

▲ GESELLSCHAFT für Huttenwerksanlagen (GHW) of Düsseldorf has perfected the design and operating practice on the carbon-lined hot blast cupola to a point where it is more than worthy of a second look by the American iron and steel industry as a means for increasing open hearth furnace production and decreasing ingot cost.

The design principles now employed more closely approach those employed in blast furnace practice than those employed in the cold blast cupola with which we are familiar.

The fumes and dust emitted from the stack of a cold blast cupola are completely absent in the new design. All the cupola gas is withdrawn from the cupola several feet below the level of the charge which is maintained fairly uniform through stock line recorders. The cupola gas is cleaned and delivered under pressure for plant use. Fifty-five per cent of the cupola gas produced is used for heating the blast. Blast temperatures of 1100 to 1200 F are continuously and uniformly maintained.

SIEGFRED TUNDER

The carbon lining in the hearth lasts indefinitely, with patching around the tuyeres every six to eight weeks. This is in contrast to shutting down every 72 to 80 hrs for relining a cold blast acid cupola.

The difference in operation between the carbon-lined, basic-operated, hot blast cupola and the conventional cold blast acid cupola is just as pronounced, if not more so, than is the design. The cupola will operate on a 100 per cent charge of the cheapest grades of steel scrap, using furnace coke. Cast iron scrap and foundry coke are not required, nor is desulphurizing. The cost of metal from a carbon-lined, hot blast cupola is substantially lower than the cost of metal produced in the cold blast cupola.

The effect of cupola metal upon open hearth production rates and costs has been definitely determined over a period of three years of operation in German plants. These results definitely establish the basic-operated, carbon-lined, hot blast cupola as the most expeditious means for increasing ingot production and reducing ingot costs.

Another use for the basic-operated, carbon-lined hot blast cupola is supplying hot metal to oxygen blown converter plants. This combination affords just about the cheapest cost in terms of production and fixed charges. Decarbonizing cupola metal in the ladle for charging electric furnaces is another application.

"THE ALL-BASIC OPEN HEARTH FURNACE"

by R. P. HEUER, Vice President and M. A. FAY, Assistant General Sales Manager, General Refractories Co., Philadelphia, Pa.

R. P. HEUER

▲ THE history of the development of the all-basic furnace, both here and abroad, is reviewed from the inception of this development in the early 1930's, to the present time. This period covers the earliest trials and developments up to and including the presently successful operations.

The construction of the present all-basic furnace is described with discussion of the changes in technique which evolved to the present arrangements, including both flat and arched roofs. The more critical factors of construction technique are identified and suggestions are made as to further possible improvements

and as to areas where further research is needed to obtain better results.

M. A. FAY

The refractories used in all basic furnaces are discussed, with emphasis on recent developments of refractories for basic main roofs. Front wall problems and their solution, back wall refractories and refractories for basic ends are discussed. The necessary characteristics for satisfactory basic checkers are described.

The operation of all basic furnaces is reviewed as to results comparative with silica furnaces in the light of the several changes in open hearth operations which have occurred in the last decade. These include the use of higher firing rates, redesign of furnaces for larger heat size and/or greater hearth area, and the increasing use of oxygen.

The present economy of the all basic furnace is discussed and comparison made with silica furnaces. A summary of the future outlook for the all basic furnace is presented including a discussion of possible improvement of open hearth operations through improved regeneration, better heat transfer in the furnace chamber, and greater furnace availability, all of which are practicable only with all-basic furnaces.

A bibliography of the literature related to the all-basic furnace is listed.

"ECONOMICS OF OXYGEN GENERATING STATIONS FOR STEEL MILL HIGH AND LOW PURITY OXYGEN APPLICATIONS"

by ARTHUR E. STEELE, Assistant to General Sales Manager, and DONALD E. CUMMINGS, Manager, Steel Mill Sales Division, Air Products, Inc., Allentown, Pa.

ARTHUR E. STEELE

D. E. CUMMINGS

▲ THE low-cost oxygen available today to the steel industry has brought forth a host of practical uses for oxygen which were only of academic interest to the steel mill metallurgist and engineer a few years ago. Among these applications are increased mechanical scarfing; expanded open-hearth use, both for decarburization and combustion purposes; carbon reduction in electric furnaces: air enrichment for blast furnaces; and recently, the top blown oxygen converter process.

This paper classifies these high and low purity oxygen applications broadly into critical and non-critical requirements from the standpoint of continuity of oxygen supply. Each application of oxygen in the steel industry is evaluated as to the most economical method of oxygen generation for the particular requirement, consistent with the desired reliability and flexibility.

"INDUSTRIES' WATER PROBLEMS AND THEIR SOLUTION"

by H. I. RIEGEL, Superintendent, Utilities Department, Kaiser Steel Corp., Fontana, Calif.

H. I. RIEGEL

▲ PRACTICES in water conservation now in effect in certain parts of the State of California will very likely be the forerunners of water conservation practices in other parts of the United States that are now considered to have plenty of water resources for home and industrial purposes. In some cases the need for action may be immediate, while in other cases the need may be in the distant future. The water supply problem in general is quality rather than quantity. This is the result of increased demand on our water resources caused by increased population with individual greater use of water, and increased industry to supply the ever expanding needs of people. The need for conservation of this valuable resource is becoming more apparent throughout the entire nation.

The discussion covers the California State Water Pollution control law and its general application. It also indicates the practices used by some industries to conserve water resources in such a manner as to make the greatest beneficial use of this valuable resource. Industries discussed will include steel, power, canneries, petroleum, citrus processing and others.

"SELECTION AND ECONOMY OF EQUIPMENT FOR BLOOMING AND SLABBING MILLS"

by KURT SCHLESINGER, Project & Sales Engineer, United Engineering & Foundry Co., Pittsburgh, Pa.

KURT SCHLESINGER

▲ THIS paper deals with the selection and economy of equipment for blooming and slabbing mills. Such selection depends not only on a thorough survey of existing and future markets but also on the ready availability and development of raw materials.

In this paper, only the selection and economy of equipment for blooming and slabbing mills up to a yearly production of approximately 1,250,000 tons is considered. Not taken into account are universal slabbing mills with a much higher output.

Analyzed are three hypothetical blooming mill plants, each plant as a separate unit, operating under different conditions with different ingot sizes, utilizing different unit production figures, and operating different hours per year to achieve specified tonnages.

Plant "A" with an annual capacity from 50,000 to 200,000 net tons of ingots considering a future expansion to 300,000 tons—A 29-in. three-high blooming mill in-

stallation is selected, suitable for rolling blooms and billets. This type of mill is generally not acceptable anymore for modern steel mill practices. Limited production and non-flexibility are its main disadvantages. However, for a very small production with limited future expansion, this type of mill, because of lower initial investment, may be considered.

Plant "B" with an annual capacity from 300,000 to a maximum of 500,000 net tons of ingots—A 36-in. two-high reversing blooming mill is described, for the production of blooms, billets and small slabs. This is a modern type mill with medium capacity. Many such installations are in successful operation, rolling either ingots to blooms or small slabs, or operating as secondary mills in conjunction with a large 44-in. blooming and slabbing mill.

Plant "C" with an annual capacity from 500,000 to 900,000 net tons of ingots considering a future expansion of over 1,000,000 tons—A 44-in. two-high reversing mill is analyzed, suitable for rolling blooms and large size slabs. This type of mill incorporates the most modern improvements and is extensively used where maximum production is a prime factor.

The analysis of blooming mills of specified production capacities must be re-evaluated and applied to conditions existing at various locations of steel plants in order to estimate the profitability of a proposed project.

"MILL GEARING AS VIEWED BY A LUBRICATION ENGINEER"

by A. E. CICHELLI, Lubrication Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

A. E. CICHELLI

▲ LONG, uninterrupted gear life for such periods as ten, or even twenty years, is the dream of every maintenance engineer in the steel industry. Such longevity has been experienced, but in this era of higher speeds and loads, similar good records are less likely to be attained. This paper reviews a number of examples of gear units in steel mill service, analyzing their performance in the light of data found in the field. Among those surveyed, were the drives and pinions of blooming, slabbing, plate, bar, rod, hot and cold strip mills. The author points out that in many cases of gear failure as revealed in the survey, there is evidence for the need of harder, tougher and more accurate gearing. Lubrication, even at its best, has not been able to compensate for the deficiency in these characteristics.

"RECENT DEVELOPMENTS IN SLABBING MILLS"

by H. J. KALBERKAMP, Chief Engineer, Mesta Machine Co., Pittsburgh, Pa.

▲ AS part of the large expansion in the steel industry over the last several years and as part of plans for the immediate future; a number of primary rolling mills have been built and several such mills are now under construction. A renewed interest in universal slabbing mills developed as maximum capacity was demanded from the mills intended for the production of slabs for strip and plate mills.

H. J. KALBERKAMP

There has been a reversal of trends in the selection of the slabbing mills. Until about twenty-five years ago most mills intended for slab rolling were of the universal type. The disadvantages and short comings of this type of mill as then in use led to the development of the high lift, two high mill with high screwdown speeds. The demand for maximum capacity and also the demand for producing slabs of sufficient width for eliminating or minimizing cross rolling in the wider strip mills has reversed the trend toward mills of the universal type.

The universal mill of modern design is a mill greatly improved over older designs. However, if the ultimate in capacity is not required, and slabs no wider than about 62 in. are to be produced, the selection of a two high, high lift mill should be given most serious consideration as such a mill has major advantages over the universal mill.

"COORDINATION BETWEEN ENGINEERING AND OTHER DEPARTMENTS"

by J. W. DePOY, Chief Engineer, Pacific Coast Div., The Colorado Fuel and Iron Corp., Oakland, Calif.

J. W. DePOY

▲ THE day of the "Lone Genius" engineer has passed. While the engineer must be competent to solve certain problems with equation and slide rule, many of the problems he must solve today are too complex to lend themselves to a one man solution.

The assistance of experts as departmental employees, outside consultants, sales or application engineers is available, and it is assumed that the chief engineer is well able to coordinate the functioning of this technical assistance. The coordination of engineering with other departments and with outside interests is a phase of modern industry that presents difficulties, but offers considerable reward when properly handled.

In the Pacific Coast Division of The Colorado Fuel and Iron Corporation, this coordination is the responsibility of the chief engineer. When a project is undertaken, he must see that the diverse needs and viewpoints of all departments concerned are fairly represented and adequately considered in the final result. This may well include sales, production, accounting, management, purchasing, customer, suppliers and others.

The coordination of these diverse viewpoints with each other, (and in some cases with those laws of nature which are the basis of engineering) may at times be difficult. Group meetings, individual conferences, discussions, investigations and reports may be needed at preliminary stages, during development and in the final stages of the project.

These things are time consuming, and may seem over elaborate, and even unnecessary at times. The final results of a well organized coordination program, however, are well worth the effort. The integration of ideas contributed by everyone concerned results in a well rounded project that cannot be developed without such coordination.

"THE FACILITY ROUND-OUT PROGRAM AT COLUMBIA-GENEVA"

by HAROLD G. DEGITZ, Staff Engineer, Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif.

H. G. DEGITZ

▲ THIS paper reviews the facilities provided at Columbia-Geneva Steel Division, United States Steel Corp., to increase the annual rated ingot producing capacity by approximately 1,000,000 tons in the last ten years. The paper begins with a discussion of improvements and additions made at Geneva and Pittsburg Works to convert a wartime facility to meet the needs of a peace time economy. The review follows the expansion programs to date, including the present round-out program which provides a sizable increase in basic steel production as well as additional finishing facilities to help meet the demand for more steel products in the West.

"SILICONE LUBRICANTS AND PROTECTIVE COATINGS IN THE STEEL INDUSTRY"

PART I—"SILICONE LUBRICANTS"

by W. H. RAGBORG, Laboratory Supervisor, and W. H. BADGER, Development Engineer, Fluids Section, Product Development Laboratories, Dow Corning Corp., Midland, Mich.

W. H. RAGBORG

▲ SILICONE fluid and grease lubricants have found a wide variety of special applications in industry. They are of value where oxidation resistance, thermal stability, moisture resistance, low volatility, and excellent consistency or viscosity-temperature relationships are essential lubricant requirements.

Because high equipment operating temperatures are quite common in the steel industry, silicones have already solved some difficult lubrication problems. The unique properties of these materials should make them interesting in still other high temperature lubricant problems associated with the steel industry.

W. H. BADGER

Development work presently under way indicates that silicone fluids with much improved load carrying capacity for ferrous metals in sliding contact can be made. Increases in high temperature stability may also be possible. Such improvements should extend the usefulness of silicone lubricants still further.

PART II—"SILICONE PROTECTIVE COATINGS"

by R. C. HEDLUND, Supervisor, Coatings Laboratory Product Development Laboratories, Dow Corning Corp., Midland, Mich.

▲ SILICONE coatings have found wide use as finishes for steel equipment which operate at high temperatures and are exposed to weathering.

R. C. HEDLUND

A number of commercial coatings are available for use on stacks, mufflers, and manifolds to temperatures of 1000 F. Others are used as industrial coatings and as maintenance finishes.

The physical properties of silicone finishes are similar to organic coatings but their properties are quite different.

A wide variety of silicone resins are available to the paint manufacturer for use in protective coatings. This paper discusses these various resins and their use in paints. It also covers surface preparations and the many applications where silicone coatings are being used successfully as coatings for steel and other surfaces.

"GREATER FLEXIBILITY FOR WIRE DRAWING"

by R. C. SUTTLE, Application Engineer, Reliance Electric & Engineering Co., Cleveland, Ohio, and MAURICE A. NYE, Chief Engineer, The Vaughn Machinery Co., Cuyahoga Falls, Ohio.

R. C. SUTTLE

▲ AT the Steel Co. of Canada's new Parkdale Works at Hamilton, Ont., extremely high finish speeds—in excess of 4000 fpm—have been attained on new continuous rod drawing machines. Placed in operation early in 1956, these machines incorporate the most recent advancements in machine design and regulated, electronically controlled drive equipment. This installation, in addi-

tion to one in the Pittsburgh area, marks the very latest in wire drawing equipment found anywhere in the world.

From the early 1920's to date, the ferrous wire industry has seen the speeds of continuous rod drawing machines advance from 350 fpm to the present day speeds which are in excess of 4000 fpm. It has been an evolution marked by a continuous process of alternately improving the machine design, the electrical drive system, and operating practices. Each of these three areas was worked on in turn until a point was reached, beyond which the speed could not be increased through further effort in that particular area. As a limit was reached in one area, effort was then switched to one of the other areas until its limit was reached, and so on in a constant rotation from area to area—reaching new plateaus of speed each time.

MAURICE A. NYE

The stages of development of continuous wire and rod drawing machines from the earliest to most recent types are traced. Details of mechanical design and the electrically controlled drive system are also discussed in detail, with particular emphasis on the actual installation at Steel Co. of Canada.

"METHODS OF CONTROL OF STRIP THICKNESS ON HOT STRIP FINISHING MILLS"

by R. A. PHILLIPS, Control Systems, Analytical Engineering Section, General Electric Co., Schenectady, N. Y.

▲ THIS paper relates to methods for closer control of strip thickness on tandem hot strip finishing trains by electrical means. It relates more specifically to the application of theory in the selection of suitable means. Such approach is desirable because of the many means to be considered and the high cost of testing and using pilot equipment. To our knowledge no automatic gage control system is presently in operation and this paper may assist in shortening the time required to produce improved thickness control.

R. A. PHILLIPS

The various causes of the deviation in the finished strip and present manual means of minimizing these deviations are reviewed. An explanation of theoretical mill behavior is used to account for present practices. This leads to a discussion of various methods of reducing strip thickness variation.

Charts are presented showing traces of the more important variables under transient and steady state conditions using several closed-loop regulating systems. The use of theory and analog computer techniques makes possible the selection of the most promising systems from among the several possibilities.

A prediction of the sequence of steps likely to be taken toward obtaining closer gage control is made and discussed.

"STEEL MILL SYSTEM STUDIES"

by D. DALASTA, General Engineer, and F. NOLAN, Application Engineer, Switchgear Department, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

▲ THE equipment which an electrical engineer operates and maintains in a steel mill has been acquired by inheritance, consolidation, integration, white sales, or studied planned purchases. Whichever of these methods has been employed in the obtaining of the equipment, it is likely that some of it is factory new and some of it may be iron-old and insulation-aged. Fundamentally, two considerations affect and condition the operation of electrical equipment. These are, first what happens to the equipment internally, and second what happens to the equipment externally.

D. DALASTA

Internally, oil may carbonize and its insulation value deteriorate, insulation may age and its dielectric strength lessen, current carrying contacts may wear and erode and their performance fall off.

F. NOLAN

Externally, the performance of the circuit breakers and other equipment comprising the distribution system may be affected by increased connected generation added either by the power company or by installation in the steel mill, increased generation acquired by connection to tie lines, addition of large synchronous motors, the installation of synchronous convertors and/or large banks of capacitors and the application of faster relaying and consequently more severe duty cycles.

If the plant distribution system is a simple radial one, the momentary currents, the short circuit currents and similar problems can be readily solved whether the plant be large or small.

In the solution of these problems the basic consideration is that the synchronous rotating machines whether they be generators or motors occasion the short circuit currents which are limited only by the total impedance of this system. To obtain a mathematical answer to how large the short circuit current or how high the momentary current the various characteristics of the system must be put on a common mathematical base.

The proper application of computers can take over much of the tedious and repetitious work involved in clerical and engineering chores. A network analyzer applied to the study of distribution systems can do this. It eliminates many hundreds of hours of slide rule work where it is properly applied.

There are less than 50 of these a-c network analyzers available in the western world. Many of their features are the results of suggestions by their users, most of whom, up to this time have been utility engineers.

Steel mill engineers have become interested in these tools as their plant systems and their problems became more complex.

Our company has available to its use two boards, one at Illinois Institute of Technology and the other at the University of Wisconsin at Madison. On these we have solved various customer's problems ranging from short circuit studies to transient stability investigations.

In preparing a system for representation on a calculator, attention must be given to fitting the actual circuit characteristics to the ranges available to the board. Doing this requires a knowledge of both the system to be studied and the limitations and possibilities inherent in the calculator. The steel mill engineer, except in unique instances, cannot be expected to be a specialist on the network analyzer. However, the boards available to him all have specialists who can translate his problems into terms which the analyzer can handle. Incidentally, this programming is perhaps the leading problem in the successful application of the digital computer to industries' problems also. The steel mill engineer, having an intimate knowledge of his mill, should definitely assist in these studies and attend them. Without him, they are often fruitless. It is the intent of this paper to discuss to a small extent the possibilities inherent in the d-c board versus the larger a-c boards which are the prime subject of the paper.

An actual example of a short circuit study on a customer's system is given wherein we have determined the interrupting and momentary currents at several points.

Probably the paramount reason and the reason why steel mill engineers will have continuing recourse to calculating boards in their future work is the invaluable aid that can be given to them on system design problems. Herein, lies the greatest opportunity for future effective work. One does not have to install the generator or the transformer or the transmission line and then investigate what effect it has had in his system. He can study these at any combination of equipment installations on the board in a matter of a few hours. Future planning groups of larger steel companies are fully aware of this and are making annual studies of their systems, and install changes and plan changes in this manner.

"THE APPLICATION OF STATIC SWITCHING TO THE STEEL INDUSTRY"

by D. LAWRENCE PIERCE, Assistant Manager Control Dept., Motor & Control Div., Westinghouse Electric Corp., Buffalo, N. Y.

D. L. PIERCE

▲ THE paper covers a brief description of what static switching is and the forms in which it is most available. The rudiments of how it works is covered and a comparison is shown of the essential differences between static switching and conventional relay switching.

What static switching can do and where it is most applicable is discussed. Examples of applications in steel and other industries are shown. Present schematic diagrams practice and wiring drawing practice are illustrated.

Samples of devices and an operating display sample are shown.

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. . . . the best way to protect ideas of company inventors is to utilize the patent laws . . . . it is also desirable to have close cooperation among the patent, engineering, production, and advertising departments . . . .

How to protect your ideas

By JOHN S. LIEB, Patent Counsel, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

▲ ENGINEERS have as many, if not more, ideas than young men in springtime. How to protect certain of those ideas which relate to mechanical, electrical and chemical fields is the subject of this article.

The history of the evolution of such ideas is a lot older than the history of protecting them. In fact the notion that an idea could have the exclusive qualities of personal property, was a long time coming. The delay may have been due to the low repute in which manufacturing was held in earlier civilizations, since much of it was done by slaves. Civilization has a history of 6000 to 8000 years, but the germinal idea of a property right in an idea emerged only about 500 years ago.

It started apparently in Italy with the sovereign giving a special license, or privilege, to certain citizens to practice a trade or useful art exclusively. The license was written in the form of an open letter addressed to the public. Since Latin was the universal language of educated men, these early letters were usually written in Latin and referred to as "literae patentes" which meant "open letters." The anglicized form of this expression, "letters patent," is still in use after 500 years except that the public has shortened the expression to "patent."

The early licenses granted in Italy were generally for pure monopolies, that is, no inventions were connected with them. However, now and then a patent was given to protect an innovation. One of the earliest known Italian patents for invention was granted in Florence about 70 years before Columbus discovered America. The inventor was a jack of all trades, being at times a goldsmith, watchmaker, shipping contractor, and a seller of building materials. His fame in patent circles, however, rests upon the fact that he patented a ship, and that his patent is one of the earliest known patents, the manuscript of which is still in existence in the Italian State Archives.

Some of the features of this early patent are worth reviewing: The claim of utility for a new invention; the refusal of the inventor to disclose his invention without just protection, in order, as he said, "that the fruit of his genius and skill may not be reaped by another without his will and consent"; his further justification for the patent grant that he might, in his language, "be animated more fervently to even higher pursuits and stimulated to more subtle investigations"; the patent's short term of three years; and the monopolistic right of excluding all others from using other new means of river transportation.

It would be agreeable to say that the inventor made a lot of money out of his invention, but he did not. His tax returns reveal that in the period following the launching of his patented boat he took a loss. As a matter of fact, the patented boat sank after a few trips with a load of marble aboard and the inventor had to pay for the lost marble.

In the year 1474, Venice passed what may have been the first patent law passed by any sovereignty.

The subject matter for which Venice granted patents gives us an accurate picture of the times. Between the years 1475 and 1550 patents were granted covering flour mills, paper mills, hoisting machines, saw mills, windmills, water mills, a method of excavating, a process for making bricks, a method of drilling wells, methods of carding cloth, powder mills, furnaces, stoves, bridge structures, glass working, a device for preventing chimneys from smoking, and even perpetual motion machines.

Since the Venetians traded widely it was to be expected that the idea of rewarding inventors with patents for inventions would be carried to other countries. England probably obtained the idea from Italy, because Italian immigrants were among the first to apply in England for patent protection.

Thus, by the early 1600's in England, a patent system was firmly established in which inventors were given the right to exclude others from practicing their inventions for a period of 14 years, which in those days was twice the seven year term of an apprentice.

The early American colonists were familiar with the British law and to some extent the colonies granted patents in form similar to the early British patents.

When the Constitutional Convention met in Philadelphia in 1787, it appeared that the delegates were not

unfamiliar with the British and Colonial patent systems because they adopted without debate the present clause in the Constitution which is the basis for the U. S. patent system. The Constitutional clause reads "Congress shall have the power to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries." This clause is the authority on which our present patent laws rest.

After the Constitution had been adopted, Congress passed the Patent Act of 1790. From 1793 until 1836 the United States had what is known as an invention registration system. There was no examination of patent applications for novelty, usefulness, invention, etc., as there is today. The inventor simply registered his invention and received a patent. In 1836 the patent laws were revised and an examination system introduced. The examination requirement has continued uninterruptedly to this day. The invention is examined to see if it is new, useful and unobvious.

The patent laws offer one way to protect an invention. There are others. An independent inventor having an idea which he wants to protect, say for a new plastic composition, may not wish to use the patent laws. An alternate way to protect his idea would be to keep it secret. But suppose he needs to raise money in order to manufacture the plastic. He approaches a prospective investor who wants to know what the plastic composition is before he will subscribe a nickel to the project. "I will tell you," says the inventor, "but I want you to keep the information in confidence."

"Nothing doing," the investor says. "I do not want to assume that liability."

The inventor, unwilling to disclose his idea on any other basis, reluctantly looks for another backer. After a number of refusals he finds one who agrees to keep in confidence his formula for the new plastic composition. The inventor then tells his backer what the idea is, feeling perfectly safe that if his backer breaches the confidence the inventor will have a legal remedy against him. But what the inventor may have overlooked is that someone unconnected either with him, the inventor, or his backer may learn of the invention by fair means, in which case that someone is free to practice it.

Let us take a particular case. The inventor proceeds to manufacture and sell his plastic. A competitor buys the plastic on the open market, fairly analyzes it, and them makes and sells the same product. Under these circumstances the inventor cannot legally prevent the competitor from manufacturing his plastic.

Moreover, to the inventor's dismay, he discovers that his competitor is underselling him on his own product, and when the inventor cuts his price to meet his competitor's, his profit has evaporated. How does the competitor do it? It is very simple.

In order to develop the plastic the inventor perhaps had to spend $100,000. On the other hand the competitor did not spend anywhere near this amount to copy the inventor's product. The competitor in this case capitalizes on the inventor's development money. This is not an unusual situation, it has happened many times.

Now suppose instead of relying on secrecy to protect his idea, our inventor had decided to rely on the patent laws. How would he have proceeded?

The first step in protecting an idea under our patent laws is to consult a competent patent lawyer. He will generally recommend that a novelty search be made to see if your idea is patentably new. There is no sense in spending money for a patent application and then discovering that John Doe obtained a patent on the same thing 20 years before. The cost of a search is generally much less than the cost of a patent application.

A search is made and it reveals that your idea is probably new. I say probably new because the search is usually limited to the collection of U. S. patents in the Patent Office, or to similar collections, and it is not usually extended to include all foreign technical publications and patents. If it were, the expense would be enormous.

On the basis of this search the attorney recommends filing a patent application. Now a patent application has been described by our Supreme Court as one of the most difficult of legal documents to draft. If it is well written it can make a good invention that is much more valuable. If it is poorly written it can destroy the value of the best invention. It therefore pays to exercise careful selection in choosing a competent patent lawyer to represent you.

The patent application is filed and eventually you get your patent. Now you have something concrete to show prospective investors or sell to some company. You have a legal document which allows you to exclude anyone else from making, using or selling your patented product, or it could be a machine or process, for 17 years. Anyone you approach can submit a copy of your patent to his own patent lawyer, and to his own engineers, and get an opinion of how good the invention is and how good the patent is.

If the invention is commercially good and the patent is well drawn, you may have something salable; but do not get grandiose ideas of how much the patent is worth. It takes more than just an invention and a patent to sell a product. Among other things, there is always sales resistance to be overcome.

So far, we have been talking about the invention of an independent inventor, but we can just as well talk about an invention made by a corporate employe, for example, an engineer, who, as a condition of his employment, has agreed to assign his inventions to his corporate employer.

The corporation, if it is a large one, will usually have patent house counsel on the payroll, who performs for the company the same functions as the independent patent lawyer does for the independent inventor or smaller corporation.

The corporate inventor in many cases has an advantage over an independent inventor. He is likely to be more familiar with the products his company makes, know the market better, and is more often exposed to problems relating to the products. It is axiomatic that inventions are usually made in response to a problem or challenge. For that reason patents of corporate inventors are often more closely related to what can, and will be sold, than patents on inventions made by independent inventors. Like any generalization, this is, of course more true in some industries than in others. But in the majority of cases the patent of a corporate inventor may afford his company better protection

than a patent of an independent inventor in the same area.

This difference between the value of patents is often confusing to the independent inventor who cannot understand why a manufacturing company which takes out patents is not interested in buying his patent, or if interested, will not meet the price he is asking for his patent. Often, an independent inventor will persist in pricing his patent above what his invention is worth, and then when his offer is refused, he feels outraged.

As an example of this, take the following case. We were about to go into production on an attachment for a tractor. The attachment had a part which represented a minor improvement. Our advertising people released advanced copy illustrating the attachment. An outsider saw the ad and promptly informed us that the attachment would infringe a patent he expected to soon obtain. When the patent was issued we found that the attachment, if produced as illustrated in the ad, would infringe a claim of his patent. Under these circumstances we informed him that we would be interested in taking a license at a reasonable royalty rather than go the expense of changing our design.

The improved part, by the way, represented an added cost of about 25¢ per attachment. However, the patent owner would consider nothing less than a royalty payment of 50¢ per attachment. Since the economics of the situation could not justify a 50¢ charge to the consumer on an improvement that costs 25¢ we redesigned the attachment to clearly avoid the patent, and then went into production. The patent owner threatened to sue us, but after consulting several attorneys, he became convinced that he had no basis for suit, because we were not infringing his patent.

A company buys a patent outright or acquires a license from an outside inventor for the following reasons:

1. The company is either making, or plans to make a product which infringes the patent, and the cost of redesign is greater than the cost of the patent, or royalties under a license; or

2. The inventor has developed a working model, which clearly demonstrates the commercial possibilities of the patented product.

When it comes to patenting an invention, however, the independent inventor is frequently reluctant to pay attorney fees for getting a patent, unless he has some assurance that he will be able to profit from the patent. This is understandable since the cost of a good strong patent may run into the thousands of dollars. The result is that more unpatented ideas than patented ones are submitted to companies by outside inventors.

The submittal of an unpatented idea to a company creates a hazard to the company that its engineers do not always recognize. In fact, the situation I am about to discuss is another important but often neglected aspect of protecting an idea.

Let us consider the following case. An engineer, employed in a department of a large company, has on his drafting board a design, completed over a three-year development period, for a new product which represents a patentable improvement over the old product. That same day an outside inventor submits to the company a disclosure of an idea for substantially the same improvement in a way which appears to create a submission of the idea to the company in confidence, or on an implied promise to pay for the idea. Since the company has developed its own idea, the outside inventor is told the company is not interested in his idea. The following year the company puts on sale the product embodying the design which it had on the drafting board. The outside inventor sees it and sues the company for appropriating his design. The company may be hard put, despite its innocence, to prove that it came by the design honestly and did not appropriate it from the outside inventor. The law is very solicitous about the rights of persons who put something of value into the hands of a trustee. A company who accepts an unpatented idea from an outsider, under circumstances which amount to an acceptance in confidence, or an implied promise to pay for the idea, is in the position of a trustee for that idea and may not profit from it without accounting to the submitter.

The legal departments of companies are well aware of the problem, but their engineers and other employes are not always so well informed. For this reason, many companies have adopted a policy of refusing to accept for consideration any ideas submitted in confidence or under an implied promise to pay for the idea, apart from a contract between the parties, and they require as a condition for considering the idea, that the submitter agree before hand, that the only liability that the company has to him, is for patent infringement, if and when he gets a patent.

But even with these precautions, situations can still develop.

One day our shops informed us that a gentlemen had submitted to them a batch of renovated files. The company uses a lot of files, so the shops were interested. They tried the files out and found them at least equal to new files. The submitter would not disclose his renovating process unless the company promised to pay him $1000 for a nonexclusive license. We had the gentleman come to our office and we talked with him. We told him that we could not agree to give him a thousand dollars for a process unless we knew what the process was. He, on the other hand, refused to disclose the process unless we paid him first. The result was a stalemate and he left.

A few months later our shops again informed us that the same gentleman had left another bunch of renovated files with them and that this second batch of files was at least equal to new files. However, this time the gentleman proposed giving our company a free license if we would give him a letter stating that the files left by him had been tried by us and found to be fully equal to new files. After some deliberation, we agreed to give him such a letter and in return we received a disclosure of the process and a free license. Our shops tried the process out, but could not get it to work and later we found a patent, which although about to expire, covered the same process. Since the process had turned out to be impractical, we chalked the matter up to experience and forgot about it.

Some months later two gentlemen from St. Louis came to see us wanting to know what we knew about this file renovating process. They also wanted to know if we had a license, and if so, on what terms. It

developed that they had bought rights in this file renovating process without knowing what the process was, for $65,000, of which they had paid $20,000 cash on account. They admitted to having been influenced somewhat by testimonials of some companies as to how good the renovated files were. They also told us, that they had been dismayed to find out, that a lot of companies had received free licenses in return for testimonials. We told them about our experience, and they left our office sadder but wiser men.

So far, some of the general ways to protect your ideas has been discussed. Now, we would like to be more specific. The patent laws set up certain conditions which an inventor must meet if he is to get a valid patent. Some of these are:

The invention must not have been known or used by others in the United States before the inventor made his invention. In other words, he must be the first inventor.

The invention must not have been patented or described in a printed publication, either in the United States or in any foreign country, before the date he made his invention, or more than one year before the filing date of his patent application in the United States.

Thus, if some magazine, either in the United States or abroad, carries an article or an advertisement describing your invention, you must file your patent application within one year of the date on which that issue of the magazine gets into the public's hands. A single copy of a typewritten thesis on a college library shelf has been held to be a publication that would bar a valid patent.

The invention must not have been in public use or on sale in the United States for more than one year before the filing date of the patent application in the United States. An invention can be in public use legally without the use being very public.

Since valuable invention rights can be lost through public use, or publication, occurring more than one year before a patent application is filed, it is important to keep close watch on public use and publication. In many companies, advertising copy is usually first cleared through the patent department so as to keep its attorneys informed about its publications. Likewise, information regarding first shipments of new products is sent to the patent department. In this way patent counsel can make sure that any patent application that is going to be filed in the United States is filed within one year of the date of first publication, or of the first public use of the invention.

If the invention is important enough for the company to file patent applications abroad, say in countries like Sweden and France, then the patent department will hold up publication approval of advertising copy and the like until the U. S. case is filed, or until the foreign patent applications are filed, if no U. S. case is filed. Publication approval must be refused or the company will lose its invention rights in those countries, because Sweden and France bar a valid patent if there has been publication anywhere or public use anywhere before the filing date of a patent application in a convention country. The convention, referred to, is an international treaty arrangement to iron out certain differences ordinarily existing between the patent laws of different countries.

What happens when the patent department of a company is not properly informed is illustrated by the following case. We happened to see a service bulletin release for correcting excessive oil consumption in engines then in the field. This release had apparently been issued almost a year earlier and we were barely able to file a patent application within the one year grace period permitted in the United States. After we had obtained our patent we would have liked to license other manufacturers under it, but we then discovered we could not do so because one of our competitors had somehow learned of the improvement and had put it into engines made and sold a little more than one year before the filing date of our patent application. This public use made our patent invalid. Thus, while our company may have obtained some prestige by pioneering this improvement, it lost possible royalty benefits.

Aside from publications and public use there are other things which must be attended to if invention rights are to be preserved.

Legal invention is a two-step affair.

The first step is conceiving a means of getting a result. Thus, if you had wanted to put marks on paper before pencils had been invented, you might have conceived of a means, i.e., a graphite stick surrounded by a wood shell, namely, a pencil, for making such marks.

The second step is actually reducing your idea to practice: in this example, actually building a first pencil.

Stated broadly, the second step of actual reduction to practice means: (1) incorporating the idea in a device, and (2) the successful operation of that device under normal or usual conditions. Reduction to practice is most important, because the courts hold that an invention is not complete if it has not been reduced to practice. However, the patent laws do provide a way which permits reduction to practice without actually building a device. The law considers that the filing of a patent application is a satisfactory substitute for actual reduction to practice. Lawyers refer to this substitute as a constructive reduction to practice.

The safest way, therefore, to protect an invention is to comply with the patent laws by vigorously reducing your idea to practice as soon as practicable after its conception, either by embodying your idea in a workable machine or developing the idea sufficiently to file a patent application. In case the working model is built first, a patent application should be filed reasonably soon afterwards.

It is important that you do this because others may be working toward the same solution. As between two persons who have made the same invention, only the first to conceive the invention has the right to a patent provided he has either reduced to practice first or was diligently working toward that end when the other person entered the field.

It is well to keep in mind that patents are only granted for a means of getting a result. They are not granted for bare ideas, or for results. As an example of a bare unpatentable idea, take the following letter which was sent to our company. To preserve the submitter's anonymity we shall call him Smith:

Gentlemen:

I am writing to you because your company might be interested in my very simple new type, machine piston that depends upon new basic energy forms in power factor advantages, involving both solid and fluid mechanics relative to molecular valence in terms of "extrinsic energy" in the form of non-coordinated force, as energy input, and "intrinsic energy" of coordinated pressure, as energy output, hereafter known as the Smith Hydro Extrinsic-Intrinsic Power Generating Unit

COMMERCIAL ADVANTAGES

The Smith Hydro Extrinsic-Intrinsic Energy Power Generating Unit will electrify an eight room house complete with light, heat, cooking and all motor power under peak load output conditions, and at an operating expense of less than one dollar per month, since it depends for its fuel on plain drinking water.

At first reading, Smith's idea sounds wonderful, but unfortunately Smith does not disclose any means for getting the result he talks about. Smith's concept, unless reduced to a specific arrangement of parts in a machine, or specific steps in a process, cannot be patented. The disclosure in its present form is therefore of no value. It is merely a bare idea.

As another example of what is meant by a bare idea, take the case of the telegraph patent of Samuel Morse. This patent had one claim, among others, which in effect read—I claim the motive power of an electric current for printing intelligible characters at a distance.

The Supreme Court rejected this claim because it merely described a result to be attained and did not describe any combination of elements for reaching that result.

The remaining claims in the Morse telegraph patent were the proper subject matter for a patent because they did describe a combination of mechanical and electrical elements which could convey telegraph signals over a distance.

The lesson to be derived here is this. When one has a bare idea, think out at least one means or method of accomplishing the desired result. Write this down promptly, illustrating it, if necessary, with sketches. Make sure the description is in terms which anyone skilled in that particular art can understand. Sign each of your papers, date each of your papers, then have someone witness them, who has read what you have written down, and understands how your idea operates. If your proposed witness cannot understand your idea, do not use him. Find a witness who does understand it. The witness or witnesses should sign and date each of your papers. Do not play fast and loose with these dates. Put down the date on which the signatures were actually placed on the paper. Avoid erasures unless the corrections are initialled by both you and the witness and also dated. Do not place any further sketches or writing on the papers once they have been signed and dated.

Your disclosure does not have to be in any prescribed legal form. Nor does it have to be placed in a self-addressed envelope and mailed to you. The important thing to remember is that you are writing a description, which should enable anyone skilled in the same field of endeavor, to practice your invention. In case there is more than one inventor, each inventor should sign and date the papers. Any other material having to do with the invention, such as letters, purchase orders, shop work orders, and engineering drawings should be carefully preserved. All this material should be signed and dated wherever possible.

The reason for all this formality is to establish and preserve evidence of your inventive act. What you want is proof of the conception of your idea and proof of the date when you first conceived it. Such evidence may mean the difference between retaining and losing important invention rights, if a contest develops at a later date over who is the first inventor.

It is well to keep in mind that any technical problem offers a challenge to ingenuity, so there will always be a number of persons responding to the challenge. It is not uncommon for more than one person in widely spaced geographical areas to independently arrive at similar solutions around the same time. The history of invention is full of such cases.

Newton and Leibnitz' independent discovery of the calculus is a famous example.

Another equally famous is the invention of the radio feedback circuit, an invention independently made by Armstrong and DeForrest. Although the Supreme Court ultimately decided in favor of DeForrest, the American Institute of Electrical Engineers insisted that Armstrong keep the medal they had awarded him for this invention. And to this day, each inventor has his supporters, who are firmly convinced that their man was the first inventor.

DeForrest won that case because he was able to produce in evidence notebook entries made by his assistant showing exactly what DeForrest had invented and when. There never was any dispute during the trial as to the authenticity of the notebook entries.

This case is a good argument for making written, witnessed and dated disclosures of inventions, since such disclosures are the best evidence of invention.

This paper will close with a brief mention of a last, but by no means unimportant, aspect of protection. In our company we call it "patent clearance."

Patent clearance is a careful study of other people's patents to find out whether a proposed new or improved product will infringe such patents.

This study should be made before a design is finalized and tooling commitments made. If the clearance question is considered early, considerable money may be saved should a redesign be necessary. Once a product is on the market it may be very expensive to redesign or obtain a license.

Furthermore, infringement of someone else's patent is a matter of fact, and not intent. The fact that you do not intend to infringe will not save you, if you do infringe. The situation is very much like selling beer to a minor. The fact that you did not know he was a minor will not relieve you of the violation.

Resolving infringement conflicts can cost a lot of money and may put your company at a disadvantage competitively. Consequently, no manufacturing operation should ever be started without having made a study of others' patents.

However, the best laid plans of mice and men have a habit of going awry. One day, one of our attorneys was looking over a new parts book. One of the illustrations reminded him of a patent he had seen. A prompt search

on his part turned up the patent. A competitor owned it and had licensed the industry on the basis of $1.50 per machine for the first 4000 machines produced in any one year, and 50¢ for each additional machine produced in the same year. The attorney got busy, made an intensive search, and was lucky enough to find an earlier patent which dominated the one in question. We were able to purchase it outright for $4000, and, as a result of owning this patent, we were able to obtain a royalty-free, cross license from our competitor, as well as licensing the rest of the industry on a basis which offset our purchase price.

Summing up, the best way to protect ideas of company inventors is by utilizing the patent laws and by having close cooperation between patent, engineering, production and advertising departments.

Some of the advantages which a patent offers are:

1. It prevents competitors from taking a free ride on your research and development money.

2. It permits your selling price to be competitive because it is not loaded with unnecessary redesign costs or unnecessary royalty payments.

3. It avoids unnecessary delays in launching a new or improved product, delays brought on by patent conflicts.

4. It provides for patents on important developments which establish the company's prestige since a patented product is exclusive.

5. It enhances salability by removing the fear that the product may infringe.

6. It creates good will among engineers by giving the inventor public recognition for his brain child.

7. It stimulates further patentable inventions within the company. It also stimulates your competitor to think of other ideas but that is a risk you will have to take along with the advantages.

BIBLIOGRAPHY

"Venetian Patents" (1450–1550), GUILIO MANDICH, Journal of the Patent Office Society, Vol. 30, p 166.

"Brunelleschi's Patent," FRANK D. PRAGER, Journal of the Patent Office Society, Vol. 28, p 109.

"The Story of the American Patent System," second edition, Washington, D. C.: Superintendent of Documents, 1953 (20¢).

"The Magic Curtain," LAWRENCE LANGNER, New York; E. P. Dutton & Company, 1951.

"Patent Laws" (a pamphlet), Washington, D. C.: Superintendent of Documents, 1955 (25¢).

Gulliksen v. Halberg v. Edgerton v. Scott, United States Patent Quarterly, Vol. 75, p 252.

"Public Use in Private, or Vice Versa," DIDIER JOURNEAUX, Journal of the Patent Office Society, Vol. 23, p 514.

DISCUSSION

PRESENTED BY

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Charles Ross: First, are there any general rules that you follow in arriving at the amount to be paid under a licensing agreement? Secondly, you mentioned the protection of having an outside inventor sign a release. How do you protect yourself when he writes a letter rather than coming in, in person?

John S. Lieb: I will answer the questions in the order in which you propounded them. There is no rule of thumb to tell you how much an invention is worth or how you should pay for it. There are various ways of buying them. You can purchase them for an outright sum; you can purchase a license under them on a royalty basis, say with a paid-up license after you have manufactured a certain number of units, or you can have various combinations of lump sum plus royalty and the like.

What may fix the worth is what the profit margin of the product will be, the percentage. Supposing your margin of profit, say, is twenty per cent, which would be a very good one in the general machinery industry.

How much of that profit is the invention entitled to? It is a question of negotiation. You probably would not want to pay out more than twenty-five per cent of that profit for the use of an invention, and a very major consideration is how much of the final product does this invention cover.

For example, on a tractor, a man might have an invention on the transmission or on a piston head for the engine. Well, actually that represents a small part of the tractor.

With such an invention you are not going to pay twenty-five per cent of the profit on the tractor. You will pay on the basis of the price of the piston, and I would say on a percentage basis, that a general machinery item can probably stand at most a five per cent royalty, but it will vary anywhere from a fraction of a per cent to five per cent depending on the invention.

Now to answer the second question you asked me—what happens if the outside inventor writes in. No one can stop you from opening your mail, but I would recommend that you at least have some sort of procedure in your company whereby the mail is funnelled through one place, and that you follow that procedure rather uniformly with each letter that comes in to you.

For example, you could have those letters go to the patent department or to some committee. You might have some one person who would get each letter and read it and he would return it to the submitter with a polite

letter informing the submitter what the company's policy is, that it is not the policy of the company to consider these ideas without having a written release, and you can enclose with your letter this release form that you ask him to sign. You can tell him that he can send the signed release back to you, and you will then consider his idea. Your letter should be tactfully written because the man may be a potential customer of the company's.

For example, in the case of the car manufacturer, you do not want to lose the sale of an automobile to this man, if possible, so that the letter should be very carefully phrased, setting out briefly why you do this, that it is for the company's protection and that you will be glad to consider his idea if he will go along with your policy, and 99 times out of 100, the man will send back his idea with that signed form. About one per cent will not, and if he refuses to do it, that I would under no circumstances consider that idea. If he sends it back, immediately return it.

If you can prove that it is a well-established policy, I do not think you will ever get into trouble. Where you get into trouble is having the letter go to the engineering department and sit around on somebody's desk for a couple of months before it is answered and then you can never prove how many people read it or who had access to it, and whether the idea was actually derived from this letter or not, presupposing that it is an idea along the lines that you are working on.

Irving Rozian: I have two questions, one a little more important than the other. In looking at patents in the steel industry, I think one great problem that comes up is the slow rate of technological change in the industry.

Very often, with a patent life of seventeen years after issue, a process has not reached its maximum economic importance in the industry until the end of the patent period or afterwards.

Is there any legal procedure by which you can deliberately delay issue in order to protect something, until it becomes of economic significance?

John S. Lieb: There is no actual way you can delay issue of a patent ethically. Let me put it this way: Many years ago, delaying issue of a patent may have been possible. The patent office procedure today is such that an applicant cannot usually delay the issue of a patent beyond minor extensions of time provided by the patent office rules.

The way the procedure works in the patent office is this. You file a patent application. The office now is running about a year to a year and a half behind in examining patent applications. So you get a letter back from them normally within a year to a year and a half. There are exceptions to that, but normally, you will not get an answer for at least a year.

Once you get a letter from the patent office and the office cites the prior art they found when they examined your case, you have six months within which to answer, and it is perfectly legal for you to wait five months if you want to.

As a matter of fact, in a patent department or a law firm, there are always so many matters to be handled that you do not often get around to answering that letter for five months. In other words, you are forced to answer it because you know if you do not answer it for six months, the application will be abandoned. The procrastination there is not as intentional as it may look.

You answer the office action and it may be another year before you get another answer, and the examiner may agree with your arguments. He may not. He may have new arguments for not issuing you a patent.

You again answer and usually you will either get a final rejection on the next office action or you will get an allowance, or you will get a mixture of the two.

A patent application contains a description of the invention and a number of claims which are appended to the end of the application. It is the claims that define the invention.

Take a patent application that has two claims in it. The examiner may reject one claim and allow the other. If the attorney had one claim allowed and one claim finally rejected and he was satisfied, he would pay his final fee and the patent would issue with the one claim in it.

Of course, you have the right of appeal. If you do not like the examiner's action in rejecting one claim, you have the right of appeal to the board of appeals of the patent office, and if the board turns you down and you still think you have a case, you have the right to appeal further. Generally, appealing is an expensive proposition. You take up an attorney's time in preparing a brief. He has to go to Washington, if he wants to really settle the case, and make an oral argument, so you do not generally appeal unless there are good reasons for it.

So that from the time of applying to the time of issue, an average patent application is pending anywhere from three to four years.

An application may stay in the office longer than that because it runs into what is called an interference proceeding. In other words, there will be two or more applications in the office by different inventors, covering what appears to be the same invention and the office sets up this interference, which is a contest to determine who is the first inventor.

The office may settle the interference as between two inventors and then discover there are some other applications in the office on the same invention, so that you may get additional interference proceedings with other parties and the case may stay in there some years. It has happened and there is really no way of avoiding it if you want all the patent protection you are entitled to.

There is a proposal in Congress now to date a patent twenty years from the date of filing the patent application and personally, I think it is a therapeutic measure because while it would create a hardship in a few cases for a few inventors, it would be better for industry all around. The United States and Canada are the only two countries in the world that I know of that date patents from the date of issue. Most of the others date them from the date of filing the patent application.

If patents were dated from the date of filing, it would be in the applicant's interest to get the patent out more rapidly. The patent office, however, is pretty careful and does not let you delay the prosecution of your patent application, if it can be helped.

John Boyko: What are the moral and legal obliga-

tions of an employe regarding patentable ideas, first, covering the products of the company he works for; secondly, on ideas outside of the company's line of products?

What steps does an employer take to protect himself covering patentable ideas of his employes?

John S. Lieb: You have hit on something that is very near and dear to the heart of many engineers, and there is a lot of feeling on this question; leaving aside for a minute any moral obligation, the real obligation, if it is to be there, should be spelled out.

In other words, when the employe goes to work for a company, if the company wants to be sure that it obtains rights on any inventions that he makes while in its employ, it should have him sign a contract to that effect.

It does not have to be anything elaborate, merely a statement that in return for employment, he will assign to the company any inventions he makes during his period of employment pertaining to the products of the company.

This would be what I would call an equitable arrangement, because in employing an engineer, I think most United States companies—this is not the practice in Europe, as I understand it—but most United States companies feel that if they are paying the engineer's salary, they are buying the ideas that he gets while he is working for them. Generally, these contracts pertain to the products of the company, so that if you are home one night and you think that the can opener you are using could be improved, and you think you have a better one, generally, the company, if it is not in the can opener business, is not going to be interested in your can opener. Our company would probably take that view and release the idea if you wanted it and wanted to sell it. A buyer of your idea would want, to know, "Am I buying something that does not already belong to some other company." We might give you a letter saying that we released any rights we might have in your idea and you were free to exploit it as you saw fit.

On the other hand, supposing you are sitting home one night and get a good idea for an electric motor and the company you work for is an electric motor manufacturer. If the contract were worded the way I said it was, your idea, since it pertains to the business of the company belongs to the company; there is nothing in your contract that has to do with what hour of the day you made the invention, so the company would have the rights in that invention.

Of course, if the contract were worded so that only the ideas you got between 8:30 and 5:00 o'clock were the company's, that might be an out, but I do not think you will ever find any contract worded that way.

If there is no agreement at all, and you get this idea on company time as a result of the use of company tools and materials and so forth, and you were not hired to develop the idea, the company has what is known as a shop right in your idea. That, is, they are free to use it. They can not assign it; but they can use it and they do not have to pay you additional pay for it.

But if there is no agreement between an employe and his company and it is clearly proven that the invention was not made on company time or with company materials, the employe is generally the owner of the idea unless he was hired for the specific purpose of developing the idea. But you get into quite an area of argument in a case like that, and the employer generally feels that the idea ought to be his and the employe feels that it ought to be his and relations are strained.

So it is better off to have a contract in writing when you come to work there, setting out exactly what your obligations are respecting inventions.

Mills Tourtellotte: You mentioned something about a doctor's thesis being on a library shelf. That poses a question in my mind. Is a thesis patented or is it copyrighted? What is the distinction?

John S. Lieb: I mentioned the typewritten thesis because we have a requirement in the law that the invention must not have been described in a printed publication for more than one year before you file a patent application.

So if the idea were disclosed in a typewritten thesis and the thesis were on a shelf available to the public more than one year before you filed your patent application, you would not be able to obtain a valid patent. The patent office may not know of the thesis being on the shelf, and they may issue a patent to you, but your competitor, if he were confronted with your patent and you were challenging him, might do some hunting and discover that thesis on the shelf, and then it would automatically knock your patent out if he could prove the date that it was put on the shelf, and in this particular case, where it actually occurred, that was done.

This merely means that if you are going to file on an invention that is going into public use or going to be published, you have to file within one year from the date of the first public use or the date of publication.

Mills Tourtellotte: What is the distinction between a copyright and a patent? Are they different? Is there a distinction?

John S. Lieb: A copyright certificate is granted for the writings of an author by the Library of Congress, if you register for it. If you do not promptly register after publication but have marked your publication properly with a copyright notice as spelled out in the law, you have a copyright from the time that you publish your article with the notice of copyright, but if you wish to enforce the copyright, you have to go through the further procedure of applying for registration, depositing two copies of your publication at the Library of Congress and paying a fee.

Patents are issued by the United States Patent Office, following the procedure of filing a written patent application and prosecuting the application to the issuance of the patent. A patent is good for seventeen years from the date of issue.

A copyright is good for twenty-eight years from the date of publication with the copyright notice and may be renewed for another twenty-eight. A copyright gives you the exclusive right to print, reprint, publish, copy and sell the copyrighted material.

In other words, when you copyright, you are putting yourself in a position to prevent somebody from copying what you have published. You are not protecting the idea that is between the pages of the book. Take, for example, a work of fiction. If someone else wants to present the plot in some other novel way and with

different conversations and different incidents and so forth, but using the basic plot, they are not infringing your copyright; they are free to do that, but when they start copying your exact words or imitating your work so that they are substantially reproducing it, they are in trouble.

Walter I. Weed: You mentioned searching patent literature. I wondered if you have to go to Washington to make a search, and is it necessary to have an attorney make the search?

John S. Lieb: You do not necessarily have to go to Washington to make the search. There are a number of private search libraries throughout the country. Most large compaines have their own search library for those products that they make.

We have quite a good one in our office at Milwaukee for the products we make. However, if you get into an area which is outside the products you make, then it is generally advisable to have the search made in Washington because the patent office has the biggest search library in the United States and has the material in it classified according to products of function. It is classified both ways. In some classes, it may be classified by function and in others by product. There are about 300 major classes of art.

In other words, there will be a class for steam turbines, another for jet engines and so forth. The 300 classes are further broken down into 45,000 subclasses. A searcher who knows where to look can scout around the correct sub-class and in a day or less, turn up all the prior art that pertains to your idea. You do best to have somebody that is at least experienced in searching. He does not have to be a lawyer. He can be an engineer that knows his way around patents. There are plenty of them, and they can make a very good search for you, as far as the novelty goes.

When it comes to an infringement search relative to somebody else's patent, claims have to be read and analyzed, generally the engineer is not experienced in construing claim language. Claims are often fifty words, one-hundred words, two-hundred words, three-hundred words long, and it takes a little practice to read those intelligently and know what they cover. That is where the lawyer collects his fee.

Kenneth E. Lewis: Supposing you have an idea and you are at present using it in your plant and do not patent it and someone else comes along and patents the idea later on, where do you stand there?

John S. Lieb: If you are using the idea and you can show it is public knowledge, then that public knowledge can bar the man that comes in later and tries to patent it.

Kenneth E. Lewis: Can he not get a patent on it at all?

John S. Lieb: That is right, but where you lose out is where it does not become public knowledge and you use it for a while and stop using it and then it is held to have been abandoned. That will not block a subsequent inventor, as long as he does not learn about it from you; that is, he arrives at it independently.

Kenneth E. Lewis: Would that not be rather difficult to prove, whether or not he learned it from you?

John S. Lieb: You may think so. There are cases both ways. It is hard sometimes to prove that something was actually in public use. You may know of what a competitor did, and you may know that he did not do anything further with it, but still you think he used it publicly. And then he gets a patent on it some years later.

You know a little bit about this factual situation and if you could prove it was in public use, you can invalidate his patent but it is hard to prove that.

All of these things are a matter of proof and after time goes by and people die or move around from job to job, it is hard to get all the facts together.

Kenneth E. Lewis: Do most of the countries in the world belong to the International Convention or subscribe to it?

John S. Lieb: There are forty-four major countries that subscribe to the International Convention. That means that if you file a patent application in any one of these countries, you have a year within which to file in another country and obtain the benefit of the priority date on which you filed in the first country, so, for example, if you file a patent application in the United States, you have a year within which to file in Great Britain and you are entitled to the priority of the date on which you filed here. That is known as the convention date, and it is a very convenient thing. It is something that is used all the time, where the company is doing business outside the United States. Russia does not belong.

Kenneth E. Lewis: In other words, when they come over and look at our equipment, they can go back and use it without infringing any of our patents.

John S. Lieb: They can pick up any of your ideas and copy them. However, even in a country that does subscribe to the Convention, if you do not patent in that country, you have no right to exclude anyone in that country.

In other words, if we are manufacturing in Great Britain and we want to protect this idea in Great Britain at the time we are protecting it here in the United States, we would have to file a patent application in Great Britain and proceed in conformance with their patent laws and get a British patent, and then we have something which gives us protection over there. If we do not we have no protection in a foreign country. Merely because this country is a member of the convention would not protect us in a foreign country.

C. S. Curtis: Does that hold true with the individual country, or does it stockpile? In other words, you have a patent in the United States and you file within a year in Great Britain. Do you have another year to file with another country, or does it hold true with each country?

John S. Lieb: No, that year begins running from the time you file in the first country. If you want to file in six countries, for example, you have to file those six applications within a year, if you want the benefit of that early date. If you do not and your application is pending over here, you could file after this year, but you would get a later date over there, and, of course, it is to your advantage to file as early as possible because you want to establish yourself as the first inventor.

C. S. Curtis: Let us say you let it run two years or any number of years, after which you file in Great

Britain. You would have a later date than you would have here.

John S. Lieb: You could not turn around and file another application for the same invention on the same date here. You could, but the office would get that second case of yours; they would find the first application, and you would have been trying to get two patents for the same invention, which is not allowed.

C. S. Curtis: Would it extend your patent rights in this country?

John S. Lieb: No. You would have to drop one of those cases because you may not double patent. You can only have one patent for one invention.

C. S. Curtis: You spoke of a printed thesis. Did you use the word "printed" advisedly or were you just referring to the fact that it would be printed? What if it were in handwriting?

John S. Lieb: I meant to say a typewritten thesis was held to be a printed publication.

Irving Rozian: Will you clear up for me the distinction between process, device, and principle of nature?

Let me cite an extreme case. Everyone credits Albert Einstein with having discovered or thought of the mathematical relationship of energy equals mass. This resulted in the entire field of nuclear power and the atomic bomb. I presume it is unpatentable as being a principle of nature.

John S. Lieb: That is correct.

Irving Rozian: In that case, do you think there needs to be a liberalization of the patent law to take into account discoveries which are not mechanical devices?

John S. Lieb: That is frequently proposed but it has never been accepted by Congress. I think perhaps there has been a little bit of fear that if scientific ideas were covered by patents, it might put a brake on the economy instead of promoting progress.

Whether it would or not, I do not know. It is a little hard to give examples. Supposing you were to give protection to the discoverer of the scientific principle; it would mean then that he would be able to exclude anyone from using that scientific principle in any number of ways for seventeen years.

Congress has never been willing to go that far.

Irving Rozian: Let me cite an intermediate case. At present, in working on the development of energy in the fusion reaction, they are doing some work on a phenomena called the pinch effect. This involves the squeezing of a stream of fast moving hydrogen ions in a magnetic field to achieve temperatures above 10,000 F.

Now, could they patent the pinch effect or would they have to patent the assembly of magnetic coils and tubes and so on, a particular assembly in which they achieve the effect.

John S. Lieb: The general rule is that you may not patent a principle of nature.

However, if you were the first man to discover the principle augmenting the pinch effect, actually the pinch effect has been known for some years, but if you were the first person to discover how to augment the pinch effect, it might be possible to cover a process for augmenting it with a claim such as this: a process for constricting the diameter of a fast moving stream of ionized particles between the pole pieces of an electro magnet, applying electrical energy to the field windings of the magnet to create a longitudinal magnetic field and pinch the stream and so forth. You might set up an actual number of steps for accomplishing a useful result.

In other words, you are working on a stream of fast moving ionized particles and you are constricting the stream of particles to a certain extent beyond its natural tendency to constrict.

I think you could possibly claim that as a process, if you were the first man to do that because you are setting up certain steps for getting results that were not known before and are useful. Generally, however, a principle of nature itself is not patentable.

In other words, we have always limited ourselves to giving the inventor the right to exclude others if he shows us a particular means of doing this. We will let him cover that broadly, but we will not let him cover all means for doing it, and that is generally the way the law is worked out.

If you have a specific combination of means for doing something, you can patent the combination of means, but you cannot patent all means for accomplishing the result.

If you could sit down and disclose all possible means and file enough patent applications, if you were that much of a genius, you might be able to cover the field pretty well, but generally, if does not work that way. You discover one combination of means and patent it and then somebody else is spurred on to find another combination of means.

Stanley J. Momot: If you are an inventor and you have devised a process for an invention that is solely applicable to government work and it has in this hypothetical case absolutely no civilian use, is it possible that you will get any royalty from the government in their use of it?

John S. Lieb: Let us say you are an independent inventor and you have made an invention that is soley applicable to the military. There is no reason why you could not sell it to the Government aside from the practical aspects of trying to interest the right people in the government.

First of all, you have to convince the military authorities that you have something that they have not thought of that is worth accepting.

If that is done, and if you have something they want there is no reason why you could not sell it to the government.

You may patent it, for example. The government, of course, is free to use your invention because it is the government, without necessarily contracting with you in the first place. You are equally free to sue the government in the Court of Claims if they use your invention without proper payment to you. As an actual, practical matter, at least with the military organization I was connected with during the war, the government attempts to work out on a contractual basis the right to use inventions of persons not in government employ and not force the inventor into the Court of Claims to get his compensation.

Stanley J. Momot: You talk about lawyers' fees and so forth. What is the average cost from the time of inception to the time that you actually get a patent application filed?

John S. Lieb: Let me answer your question this way:

It depends entirely on what your idea is. I would say that the average lawyer in practice would feel that he should get at least $20.00 an hour for his time.

Out of that $20.00, he is going to have to pay office rent, secretarial salaries, buy books for a law library which can be expensive, telephone, paper, typewriters, etc. So, say he gets a minimum of $20.00 an hour.

Suppose your patent application is for an invention that is a fairly simple thing and he can draft your application in thirty hours. That is $600.00. That would be the charge.

But supposing it is very complicated and he is in and out of your factory for six months and there is quite a few drawings and pages and so forth, you may get a bill for $10,000 or $15,000 without any trouble.

James Laidlaw: Supposing that one of the engineers, who had signed off with his company had been working on something, discovered and solved a problem after 4:30 or 5:00 o'clock and he knew that he really solved it and that it probably was worth lots of money. Legally, could he have someone else file a patent for him?

John S. Lieb: No. A patent application must be filed in the name of the inventor.

James Laidlaw: Supposing he had a friend who was an engineer. Say, it was some kind of an electrical device that only you make; could someone else file it? Could they come to some agreement, he and the other fellow? Could they patent the thing outside of your company?

John S. Lieb: Of course, you can do anything, but you would not have a valid patent if you had someone else file a patent application in his name for an invention that you made. He would be swearing to a false oath because he has to swear that he is the first and original inventor when he files that patent application and he signs his name to that oath.

The attorney, of course, if he knew it and went ahead with the case, would open himself to disbarment if the facts became known.

Suppose he does not know it; he is fooled and the case goes to issue and the patent issues, and then later on, it is found out and can be proven, then the patent is no good. That happens occasionally.

I do not say necessarily that this arises because of fraud, but occasionally, you may find a company, the chief engineer does not know anything about patents; he has had a small hand in the development, no legal advice is sought. He said, "Put the patent in my name" and it is filed in his name.

The engineer that really made the idea also is not familiar with patents and he says, "OK" and does not think anything about it. A couple of years go by and he leaves this company's employ. This is an actual case that I am giving you. It happened between two companies. The inventor went over to the other company and they said, "What about this process?" And he said, "Oh, I developed that" and they said, "It is in the name of the chief engineer over there." And then he said, "Well, he did not make the invention, I did."

The second company started to use the first company's process and the first company sued the second company for infringement. The second company was able to prove that the patent was not in the inventor's name, and the patent fell.

So it is very important that the real inventor's name be on the patent.

If the chief engineer, for example, were named as a co-inventor here, through error, and it later developed that he was not the inventor and such error arose without any deceptive intention on his part, the law has a procedure whereby you can drop his name off without any trouble.

In the old days that would have made the patent invalid. You now can drop the noninventor or if you do not have all of your inventors on the patent that should be on there, they can be added, but if you have a patent that is issued in the name of one man who is not the inventor, the patent is no good.

Of course, like anything else, you have to prove your assertion because a patent is presumed good unless you can show it isn't.

C. S. Curtis: We have been discussing here the pros and cons of people inventing during company time. You cite an agreement with your company.

Now, supposing that I and another man, are working on an idea. I am working for one company and he works with me on an idea and we develop it.

How much does my company have an interest in the idea?

John S. Lieb: As you pose the facts, you have an engineer from one company and an engineer from another company and you are co-inventors. Unless there is some agreement signed between the two companies, and supposing that the companies have had each engineer agree to assign his inventions to his company, each company has the right to do what it likes with that invention, with that patent, say, regardless of the other company.

C. S. Curtis: Take, for example, the case of an independent inventor and somebody working for a company, that is what I had in mind.

John S. Lieb: Say they are co-inventors and one undivided half interest is the company's and one undivided half interest is the independent inventors. If there is no agreement between the independent inventor and the company of how they will dispose of this patent right afterward, or how they will sell it or license it and so forth, each is free to go out and license it as he sees fit. Broadly speaking that means that the rights each one has are not worth very much, because if each is free to license the patent and one gets ahead of the other he can license everybody before the other is out the front door. With this result a company is going to be very wary about going in on a development program with an outside inventor or with another company, unless they have an agreement with him or with the other company before hand, which will spell out how any patent that comes out of the development program will be handled.

In other words, if it is a joint development, then one party or the other may license with the approval of the other party and they will divide the receipts such and such.

If this is not done, each one is free to collect all the receipts he can get. The net result is if somebody came in the door with a half interest to sell; we say, "What agreement have you with the other inventor?" and he says, "None." Then we are generally not interested because what he has to sell is not worth anything to us unless we are able to buy the other half too.

By
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Extremely heavy construction characterizes the facilities and buildings of steel plants.

The Design of Mill Buildings

▲ THE subject of mill building design is a neglected stepchild in the field of engineering literature. In spite of the great investment in industrial construction, little attention has been given to the importance of the design of the heavy mill structure. This is in spite of the fact that the problem of process housing is common to all industry. It is, of course, natural and correct that the design of the structure should take a position secondary to the engineering of the primary process. However, the importance of the safe, adequate but economical structure must be recognized. It is noteworthy that the literature reveals so few papers devoted to this field.

The people who should be most vitally concerned with the cost and adequacy of a mill building are the owners, and among the owners, the primary steel producers erect the largest dollar volume of heavy mill-type structures. A review of the design specifications now in use among these firms has revealed that the technology in this field has lagged.

One company has not revised its specifications since 1930. Another has not written design specification or procedure, and several companies offer standard specifications which are merely a recital of the allowable stresses recommended by the American Institute of Steel Construction. These AISC specifications are incorporated by reference in practically all current design specifications, and this is appropriate, but it should be emphasized here that mere compliance with these specifications will not necessarily guarantee a mill building of acceptable design. The AISC Building Code offers no guidance to a mill building designer on the question of the nature of the basic structural action of the mill frame, and this is obviously fundamental in any search for a rational approach to column design. Other variations in specifications involve snow loads, wind loads, allowable stresses, coincidence of crane loads on a single span, and percentage allowances for impact, side thrust and longitudinal thrust. Some of these differences result from varying climate or statutory building code requirements and will be subsequently discussed in more detail, but none of these are as important as the differences in basic assumptions of frame action.

Much test work is needed to obtain the data which is necessary to most effectively design mill building and crane runway structures . . . . these are a source of much trouble for many plants today . . . . the following paper suggests a design procedure which should eliminate many of these problems and one which should be considered by anyone concerned with mill building design.

The loading of the structure may be considered a subject of first importance in the design of this building, as it would be in the case of any structure. In the case of the heavy mill building, the dead load, wind loads, and actual crane wheel loads and spacings usually may be readily obtained. Beyond this point, however, wide disagreement exists. Basic percentages for vertical impacts vary; some use 20 per cent, some 25 per cent of the crane wheel loads. One authority uses a percentage for the first crane only on the span, and if two cranes can be placed on the span, impact is omitted entirely. This same authority carries no impact into either column or foundation. For horizontal thrust from trolley racking or bridge travel, there is also a general lack of agreement. One common practice is to use a fixed percentage, say 10 per cent of crane wheel loads for side thrust. Another authority tabulates a series of various side thrust requirements for cranes used in differing services. It should be mentioned here that the basic reasoning behind the use of 10 per cent of wheel loads lies in the accepted fact that the coefficient of friction, steel to steel, is 20 to 22 per cent. Thus, for side thrust generated by trolley acceleration, the theoretical amount would be equal to 20 per cent of the weight of the driven trolley wheels. Likewise for the longitudinal thrust, the wheel loads on driven wheels times 20 per cent should result in an adequate longitudinal loading. There is a general lack of experimental dynamic measurements of these horizontal effects. Since the effects are momentary, they cannot be measured, except through the use of dynamic strain measuring equipment. The AISE sponsored a limited series of tests on vertical impacts on crane bridge girders. These tests (1)* seemed to indicate that vertical impacts in slow-moving cranes on adequately maintained runways were not a critical problem. There are, however, no valid experimental strain measurements for side thrust effect known to the authors. Furthermore, great refinement in determining these values in the field would not only be unnecessary, but meaningless. This is so because the runway girder is not only subject to forces created by accelerating and decelerating the trolley, but also to the effect of the trolley hitting the bumpers. This effect is very difficult to calculate, since the trolley bumper is usually of rigid or rail-bumper design.

In the case of the runway bumper, where springs or draft gears are normally used and the bumper is of adequate design, the likely maximum longitudinal thrust can be analyzed with greater assurance of accuracy.

While personal observation of the operation of a mill often leaves one with the impression that it is almost impossible to over-design, it must be recognized that the design should evaluate the likelihood of coincidence of loading. Equal results would, of course, be obtained either through the use of higher stresses, or by assuming that certain coincident maximum loading conditions cannot obtain. It is the authors' opinion that this cannot be fully legislated by specification, but must be subject to some judgment in each individual case. A further consideration which has to be weighed by the management is the possibility of increased unit loads, a trend which has shortened the useful life of many structures because they could not be economically reinforced for larger heats or heavier coils.

Of equal importance to the subject of loading is the subject of allowable unit working stresses. Insofar as allowable stresses are concerned, there is no better agreement among the various authorities than there is in the case of loading. Some authorities use the straight AISC specification with 20,000 psi unit stress. Some authorities use a mixture where structures not carrying hot metal loading are permitted the 20,000 psi basic stress and buildings which do carry molten metal are restricted to 18,000 psi. The basic reasoning behind this, of course, is to provide some additional factor of safety for the structure with the additional hazard of the hot metal.

In the preceding paragraphs, the most important of the disagreements in the area of loading and allowable stresses have been itemized. Beyond this point, the accuracy of the analysis will be our only concern. It is certainly unreasonable to imply that an economic structure can be produced through the judicious choice of error in design. The implication is obviously ridiculous. On the other hand, it may be stated that the more reliable design procedures will reduce the necessity for the use of conservative unit stresses or over-conservative loadings which would be required to compensate for potential design errors. Omitting from consideration the design of purlins, roof trusses, girts and secondary members, the design of which needs little elaboration, calculations illustrating design practice in the two principal mill building elements; the crane runway girder and the crane column, will be presented.

In a discussion of crane girder design, it will be assumed that the reader is familiar with the mechanics of determining maximum moments and shears for given conditions of span and loading, and the illustration to follow will deal with the selection and analysis of a section that is adequate and economical for these loads. It is proper that the philosophy of this design practice should be reviewed here. Traditionally it has been assumed that the principal section of the girder carries vertical load effects and that the top flange, including stiffening material, carries the horizontal load effects. The results of the 1941 AISE crane investigation (1) throw some doubt on this assumption. These experiments with bridge girders demonstrated that the whole section participates in both types of loading situations. However, the practice of stiffening the top flange has resulted in safe designs since the structure tends to resist loads in a manner paralleling the efforts of the designer to provide stiffening material. The sample analysis chosen is a typical example of a moderate size crane girder. The geometry of the structure determines the over-all dimensions. Closely related to the geometry of the structure is the problem of physical clearances for safety reasons. Most safety departments in the steel industry have rigid requirements for clearances between crane end trucks and column top shafts. The purpose of this limitation is obviously to prevent catching a workman between the end truck and the column. One company requires that this clearance dimension be a minimum of eighteen in. This is considered the safest practice, but the effect on useful width of building is obvious. Another common practice is to permit clearances less

* Numbers in parentheses refer to Bibliography at end of article.

than four in. or greater than 18 in., but not between. The small clearance option is offered with the idea that a man would be pushed to one side instead of being trapped. This feature of runway clearance is stressed because of the surprisingly large number of accidents which have occurred, particularly on runways with improper clearances.

On the basis of preliminary calculations and the designer's experience, a trial section is selected. (See Figure 1). Note that the ratio of span to depth of girder is usually kept to a maximum of 12. When clearance requirements dictate shallower construction, additional section modulus is furnished so that the deflection will not exceed that which would have occurred had the proper depth girder been used. Mathematically, such a girder is proportioned by moment of inertia rather than section modulus. It should be noted that the final analysis of the section is based on the so-called "exact" method. The main section is first analyzed (Axis: 1-1). While all rivet holes below the neutral axis are deducted, the location of the neutral axis remains at the point determined by the gross section. The computation of section modulus for the top flange is determined using gross section moment of inertia, and the section modulus for the bottom flange is determined using the net section. This follows railroad practice and is based on the observed fact that the neutral axis does not jiggle up and down at points where rivet holes occur.

The horizontal section is now analyzed. Conventionally, the top half of the main section plus the lateral plate and back-up material are considered to act together. No rivet holes need be deducted. The tensile and compressive stresses may now be computed and added to those obtained in the analysis of the vertical section. Provided these are within the allowable range, the section may be considered satisfactory. If the stresses are excessive, or if the design looks overly conservative, the process must be repeated. An important point of difficulty is the determination of the allowable compression stress in the top flange. Admittedly, the AISC ld/bt formula is not applicable to the case of built-up girder construction. The customary practice is to use an l/b formula of the general form of the 1936 AISC Code. Although the AISE requirements permit l/b ratios of 65, this is intended primarily for box section crane bridge girders. The use of some judg-

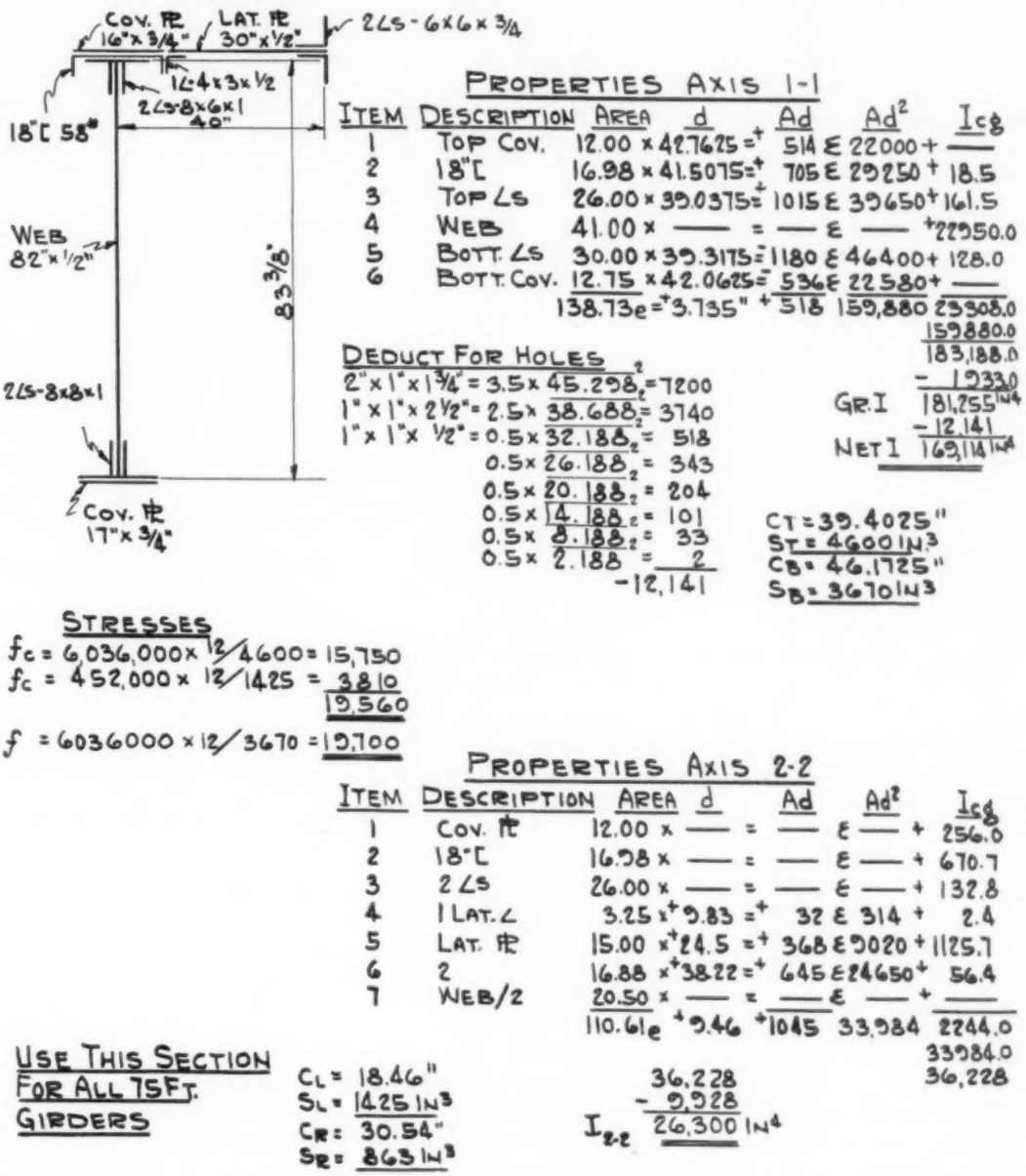


Figure 1 — The first step in the design is to select a trial section. This design is for a 75-ft span in a 125-ft bay (back-up girder).

ment in this instance rather than rigid adherence to formula is indicated. It should not be necessary to further describe the rather simple mechanics of crane girder design. Rather, it is worthwhile to note some of the fairly obvious but not always observed rules which should be followed in crane girder design.

First, the design of the fasteners has been the source of some difficulty in crane girders. Experiments comparing hot-driven riveting, cold riveting, and high-tension bolting have been performed by the AISC. While high-tension bolting has shown great promise, the cost is not favorable for shop work. Cold riveting has fallen into disrepute as a result of recent tests. It is considered good practice to use the so-called "precise" $v = VQ/BI$ formula for calculation of rivet stress, but it is preferred that maximum spacing should not exceed six in. The rivets connecting the lateral plate to the top flange should have very conservative spacing, since calculations as made do not adequately express the actual rivet stress, especially in view of the stress reversals which may occur. The connectors fastening flange angles to web are a source of difficulty since not only must the horizontal shear be provided for, but the direct wheel load reaction must also be carried.

This concentration is usually assumed distributed over a 2 ft, 0 in. length. One solution to the problem which is not universally accepted is the practice of fabricating the web plate flush or projecting $\frac{1}{32}$ in. above the back of flange angles to pick up the wheel loads directly. It is recommended that rivet spacing be given careful consideration to design since riveting inadequacies frequently result in difficulty with loose rivets in service.

Second, consideration must be given to end bearing conditions. It is disturbing to find how frequently the end reactions are not properly provided for. The designer should sketch the design of the girder end, showing the method of handling the reaction through stiffeners properly carried into the supporting column material.

Third, precautions must be taken in the design and detailing of the end connections to avoid restraint of the girder against end rotation. Special designs are often used to physically separate the ends of the girder. One of these which has been patented was described in earlier papers in the AISE literature.(3,4) Some end details of a very unsatisfactory character have been used in the past. One in particular provided for riveting directly between the girder web and the column. This application resulted in 38 loose rivets in a 72-rivet group, while in another instance of this type in which the rivets remained tight, the column flange angles cracked at the fillets in service.

Fourth, adequate provisions for torsional stability must be made. Experience has indicated that any girder having a span much over 30 ft can be torsionally unstable unless stiffened at the bottom flange as well as the top. One girder of 65-ft span, without bottom chord stiffening could be excited into torsional vibration by manually pushing it in synchronism with the natural mode of vibration. This means that a full back-up girder is needed for spans of any magnitude, say 30 ft or greater, instead of simply stiffening the top flange by means of a top or side channel.

Fifth, a very desirable if not essential practice on girders for outside service is the use of a wearing plate between the rail and girder flange. Lacking such wear plates, many girders have been found with the top flange angle virtually worn through after a few years of service. The practice for indoor runways varies. In this case, the wear plates are not as critically essential, although cases of considerable wear have been recorded.

Sixth, one practice not recommended by the authors is the use of knee-braces attached to the crane girders to provide longitudinal bracing for the building. This practice can be expected to result in loose rivets in the knee-brace, transverse strains in the column, and it generally fails to accomplish the intended purpose of bracing the building during its service life.

The second principal element of design in heavy mill building construction is the crane runway column. There is greater disagreement in this element of design than in any other in mill building work. It must be admitted that perfectly satisfactory column designs

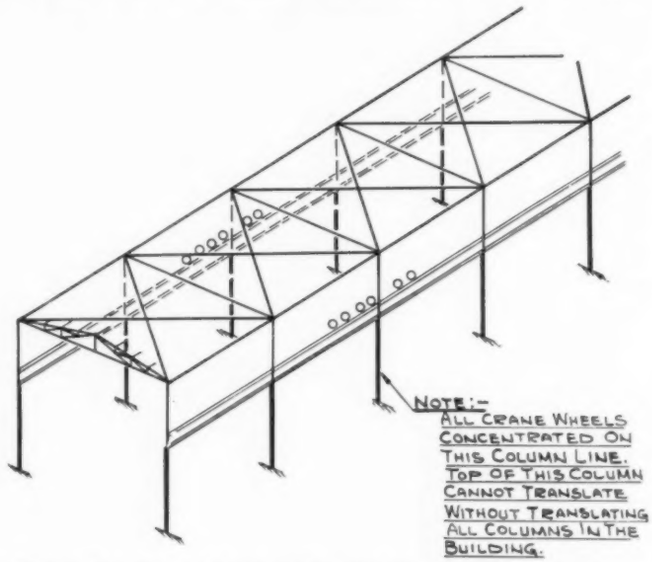

NOTE:-
ALL CRANE WHEELS CONCENTRATED ON THIS COLUMN LINE.
TOP OF THIS COLUMN CANNOT TRANSLATE WITHOUT TRANSLATING ALL COLUMNS IN THE BUILDING.

Figure 2 — Isometric view illustrates space frame concept.

dating back to before the turn of the century have been made. At the same time, it is difficult to see just why methods should be so crude as to produce misleading or even grossly incorrect results. This is not intended to imply that the authors are the sole users of refined methods of column analysis. Actually, similar practices are used by others, and have been for some time. Unfortunately, one of the largest designers and owners of mill buildings still assumes the building to be a portal, with an assumed point of inflection at the mid-height of the column. This assumption of plane frame action is not confirmed by any theoretical or experimental evidence. In fact, the testing work to be described in the ensuing paragraphs refutes such an assumption.

A significant contributing factor to the perpetuation of this column design procedure which hopes for proper results by attempting to balance two grossly erroneous assumptions of opposite sign is the prevalence of a structural design textbook advocating this procedure in many of our engineering colleges.

A typical long mill building properly designed on the basis of plane frame action would be an exceedingly heavy structure—one that few managements would care to finance. There are applications for such designs

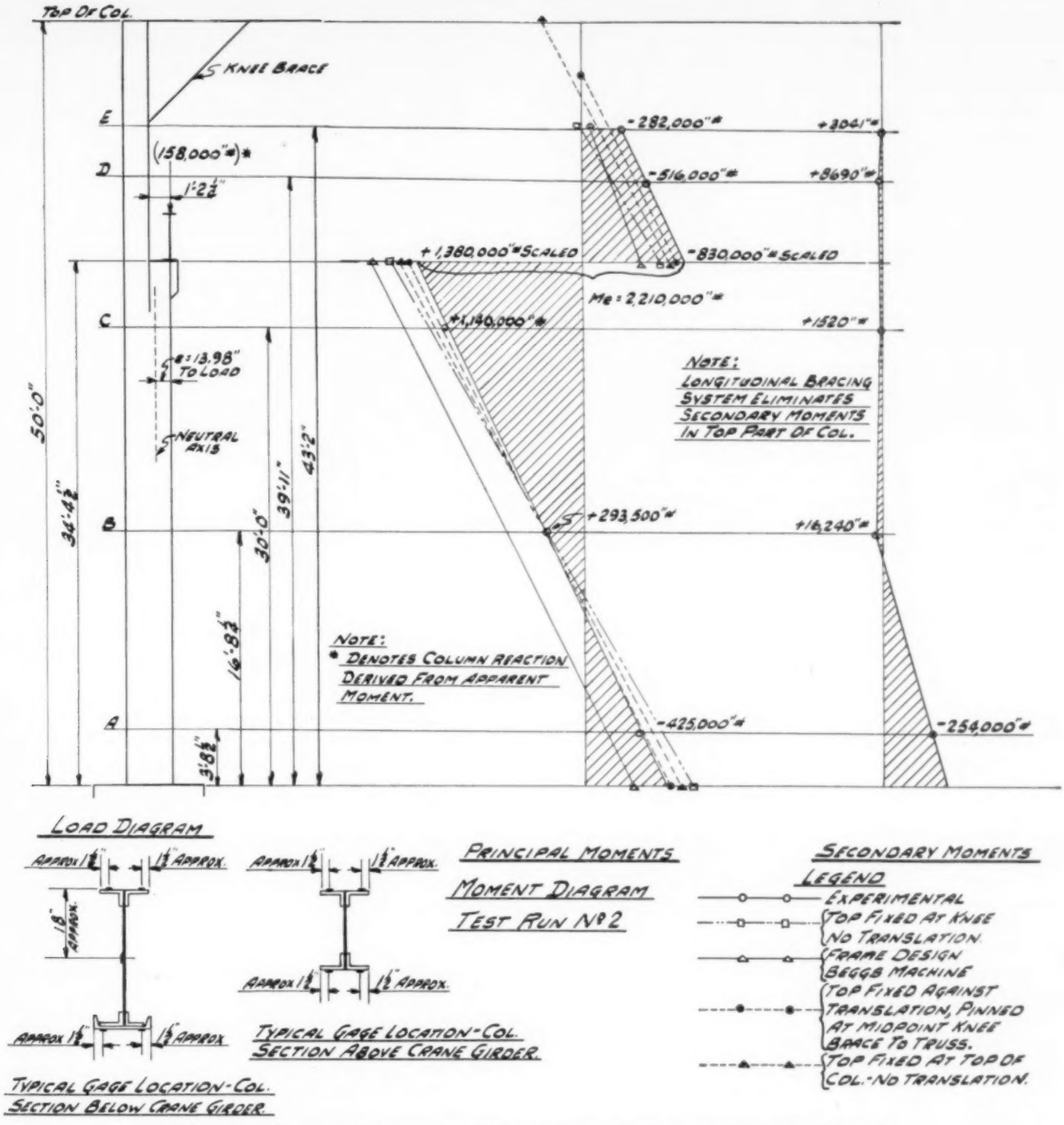


Figure 3 — Diagram shows results of strain measurements made on mill columns.

on rare occasions, i.e., a three-bay skullbreaker structure where the building is so short that crane loads cannot be successfully distributed to adjacent bents.

Two very important considerations determine the basic conditions of design of the mill building frames. The first of these is the fact that it has become uniform practice to provide full-length bottom chord bracing. This practice has resulted from field experience which demonstrated the superiority of a structure provided with such a continuous bottom chord bracing system. The second key point is the fact that the maximum condition of live crane loading can occur at only one column at a time. Thus, the top of the column is prevented from translation because of the fact that the bottom chord bracing transmits horizontal forces to the unloaded columns which resist such translation. For these reasons, the structure may be considered to be, in effect, a space frame. (See Figure 2). It will become apparent that for the isolated loading condition which prevails in a structure of average length or longer, this may be considered a simplifying rather than a complicating assumption.

The crane column may be taken out of the space frame and analyzed as a "free body" or isolated member. The validity of this practice has been established by full-size testing. A column in a multi-bay building in the Cleveland Works Division of Jones & Laughlin Steel Corp. was selected for this test. The column was located in a new section of building in which adequate testing could be carried on without disturbance to

operations. The original design of the building, including the column under test, was based on plane frame analysis made on a Beggs machine model. Actual strain measurements were taken on the column, using SR4 electric strain gages. The loadings were restricted to eccentric moment loads for practical reasons. The accompanying illustration, (see Figures 3 and 4) shows that three strain stations were located on the bottom shaft (to establish a straight line) and two on the top shaft (to establish a straight parallel to the line on the bottom shaft). It is interesting to observe the comparison of the measured moments with the various design assumptions. As was expected, a very wide variation between the experimental results and the Beggs model analysis was found—not because of error in the analytic procedure, but because of error inherent in the basic concept of plane frame action. Observe that the Beggs model value for moment at the base is only about 50 per cent of the experimental value.

Several assumptions were made and tested by comparing computed with experimental moments. As can be observed in Figures 3 and 4, the best correlation between calculated and measured moments occurs when the base of the column is assumed fully fixed and the top pinned midway between the knee-brace and the

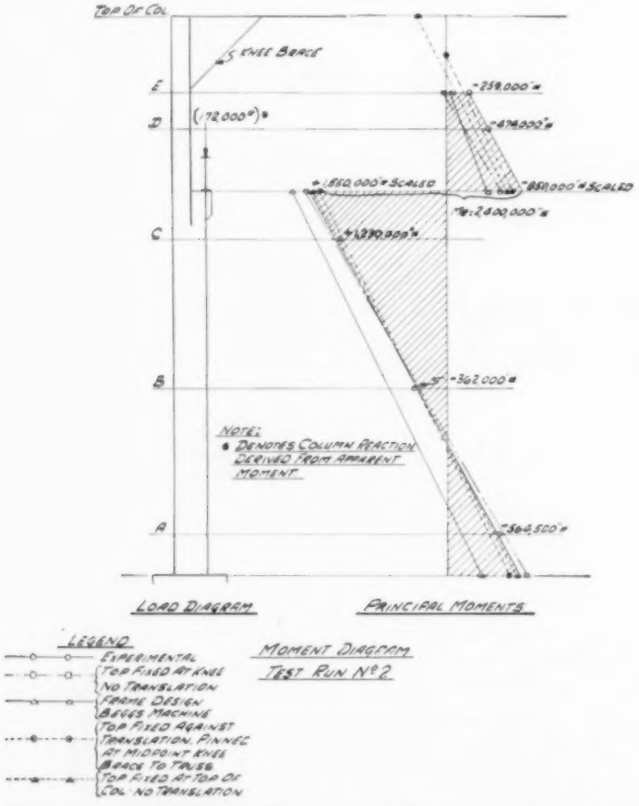


Figure 4 — Additional data on strain measurement are given on this sketch.

bottom chord of the truss. It is recognized that differences in construction may affect the logic of these assumptions, but for the general case, no more logical approach has been found. A principle of column design for crane load effects may now be stated as follows: "The column shall be considered as fixed at the base against translation and rotation and pinned at the top for rotation at a point midway between the knee-brace

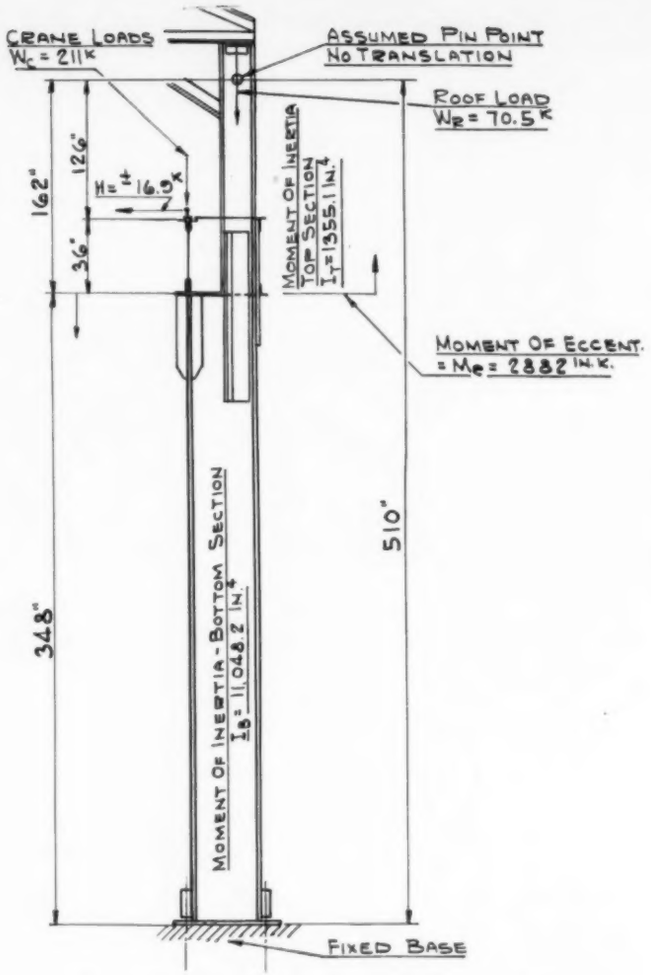
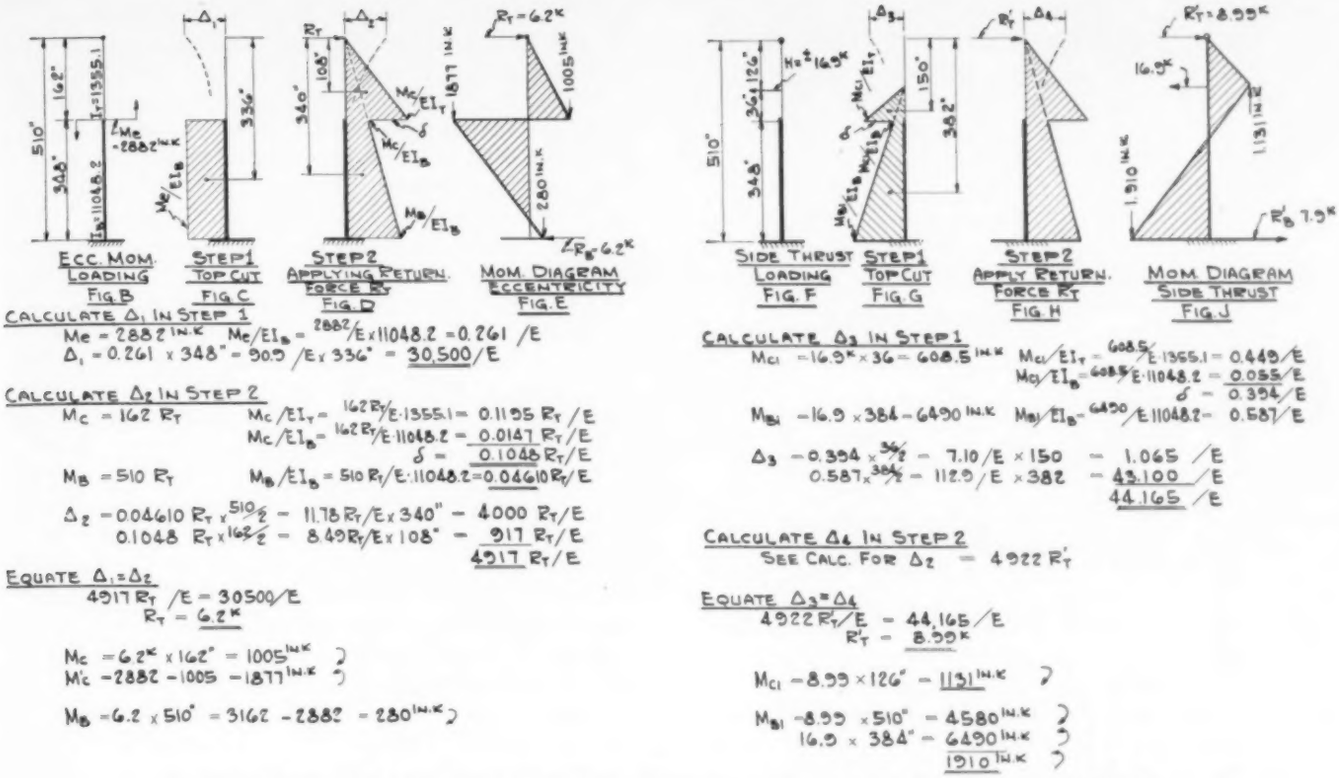


Figure 5A — Load diagram for typical column.

and the bottom chord of the truss. No translation of the pin (side-sway) is allowed." While this may be considered a simplifying assumption, it is evident from Figures 3 and 4 that the error is extremely small—in the range of 3 per cent or less.

Let us see the effect on design analysis that this basic principle may have. As in the case of any statically indeterminate analysis, a first approximation, or designer's guess, must be made and then investigated. Some experience is required to produce a first approximation which can be expected to prove reasonably accurate. Having determined the trial proportions of the column, the physical dimensions, loadings and properties of the sections may be determined and shown as in Figure 5A. To the experienced designer, it will be evident that several methods, including the classical method of least work, may be applied to the solution of the column. However, a rapid but completely generalized solution has been developed which offers the advantages of easy understanding and mathemetics which need not go beyond simple geometry. The method is an application of the moment-area principle, and proceeds as follows:

Figure 5B shows the load diagram for eccentric moment, and Figure 5C shows the column "cut" at the top pin, releasing the top, and super-imposed on this is the applicable M/EI diagram for this condition. The deflection "delta one" is readily calculated, and by moment-area theorem is equal to the moment of the


ECC. MOM. LOADING FIG B
STEP 1 TOP CUT FIG C
STEP 2 APPLYING RETURN FORCE Rt FIG D
MOM. DIAGRAM ECCENTRICITY FIG E
SIDE THRUST LOADING FIG F
STEP 1 TOP CUT FIG G
STEP 2 APPLY RETURN FORCE Rt FIG H
MOM. DIAGRAM SIDE THRUST FIG J
CALCULATE Δ1 IN STEP 1
Me = 2882 IN.K Me/EIB = 2882/E x 11048.2 = 0.261 /E
Δ1 = 0.261 x 348" = 90.9 /E x 336" = 30,500/E
CALCULATE Δ2 IN STEP 2
Mc = 162 Rt Mc/EIT = 162 Rt/E·1355.1 = 0.1195 Rt /E
Mc/EIB = 162 Rt/E·11048.2 = 0.0147 Rt/E
δ = 0.1048 Rt/E
MB = 510 Rt MB/EIB = 510 Rt/E·11048.2 = 0.04610 Rt/E
Δ2 = 0.04610 Rt x 510/2 = 11.78 Rt/E x 340" = 4000 Rt/E
0.1048 Rt x 162/2 = 8.49 Rt/E x 108" = 917 Rt/E
4917 Rt/E
EQUATE Δ1 = Δ2
4917 Rt /E = 30500/E
Rt = 6.2K
Mc = 6.2K x 162" = 1005 IN.K
M'c = 2882 - 1005 = 1877 IN.K
MB = 6.2 x 510" = 3162 - 2882 = 280 IN.K
CALCULATE Δ3 IN STEP 1
Mc1 = 16.9K x 36 = 608.5 IN.K Mc1/EIT = 608.5/E 1355.1 = 0.449/E
Mc1/EIB = 608.5/E·11048.2 = 0.055/E
δ = 0.394/E
MB1 = 16.9 x 384 = 6490 IN.K MB1/EIB = 6490/E 11048.2 = 0.587/E
Δ3 = 0.394 x 36/2 = 7.10/E x 150 = 1.065 /E
0.587 x 384/2 = 112.9/E x 382 = 43.100 /E
44.165 /E
CALCULATE Δ4 IN STEP 2
SEE CALC. FOR Δ2 = 4922 R't
EQUATE Δ3 = Δ4
4922 R't/E = 44.165/E
R't = 8.99K
Mc1 = 8.99 x 126" = 1131 IN.K
MB1 = 8.99 x 510" = 4580 IN.K
16.9 x 384" = 6490 IN.K
1910 IN.K

Figures 5B through 5J — Steps in typical column analysis are given in this series of figures.

moment areas about the pin or deflected end. Figure 5*D* shows the M/EI diagram for a restoring force "R_t." The deflection of the pinned end under this loading (only) "delta two" can also be readily calculated. Since the original design premise was based on the condition that the top does not translate, "delta one" must equal "delta two", and the resulting equation may be solved for "R_t." Having acquired a value of "R_t," it is a simple matter to develop the moment diagram, Figure 5E. In a similar manner, Figure 5F shows the load diagram for side thrusts. Figure 5G shows the resulting "delta three" when the column is cut through the pin, and Figure 5H shows the "delta four" caused by a restoring force R_t'. "Delta three" and "delta four" may be equated and R_t calculated. Having secured R_t', the moment diagram for this effect (Figure 5J) is constructed as before. Provided the column is located in a structure having multiple aisles where wind stresses may be neglected, the analysis is complete.

The entire column analysis, including determination of properties of sections, should not require more than two or three hours for the experienced designer. The designer will now sum the axial and bending stresses at various sections along the column and compare these with allowable stresses. The designer is cautioned here that consideration of longitudinal moments resulting from eccentricity of crane loads transverse with the column axis must be considered. This is usually a separate case, involving a maximum reaction of one crane girder only. One major advantage of the method is that changes in magnitude of loadings can be evaluated by simple proportioning. This would not necessarily be the case if all conditions of loading were considered simultaneously.

The problem of wind stresses in the single-aisle structure will now be considered. In this situation, the wind stresses may not be safely ignored without adequate confirming calculations. An examination of the problem indicates that the simple space frame analysis may no longer be used, since each bent must resist its own share of the wind load and consequently side-sway may be presumed to occur, although this point is not founded on experimental observations. When side-sway occurs in a frame of this nature, it is customary to assume that the column is fixed at the bottom of the knee-brace against rotation. Fortunately the mechanics of solution used in the previous crane-effects problem may be applied here with only minor variations. The problem may be considered in two parts—roof wind and wind on the column proper (side wind) (Figure 6). It is obvious that with columns of equal stiffness, this load will be equally divided between the two columns. It may therefore be assumed that an "R_t" due to roof wind is applied at the top of each column. When the column is "cut," a deflection and a rotation of the top result. A simple calculation (Figure 7) is required for a restoring moment at the top, "M_t." This portion of the wind analysis is straightforward.

The analysis for side wind is somewhat more complicated. Figure 8 shows the loading diagram for side wind only. Assume that the windward column has been cut and the resulting deflection calculated as before. This column, however, is connected to the unloaded or leeward column. A little reflection will make it evident that, if the columns are of the same stiffness, the connecting member will restore the windward column one-half of the original deflection. The resulting force "R_t''" may be readily calculated from this fact. It is now a simple matter to establish the necessary equations for the restoring moments at the top of each column and a final

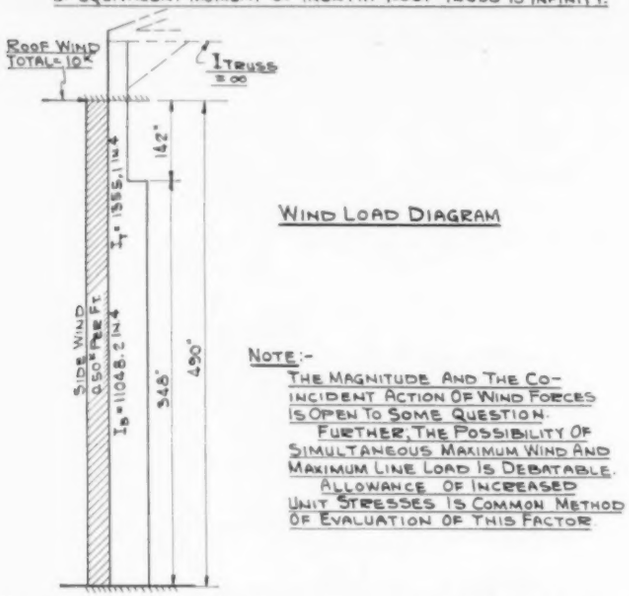
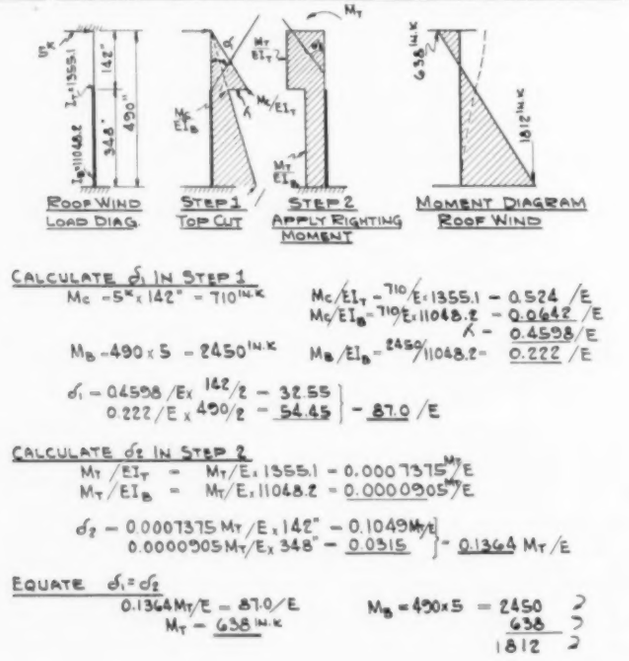

WIND LOAD; BASIC ASSUMPTIONS
a. EACH PLANE FRAME CARRIES OWN SHARE WIND LOAD.
b. BOTTOM FIXED.
c. TOP FIXED ROTATION AT KNEE BRACE-SWAY PERMITTED.
d. EQUIVALENT MOMENT OF INERTIA ROOF TRUSS IS INFINITY.
ROOF WIND TOTAL=10K
I TRUSS = ∞
142"
348"
490"
SIDE WIND 050 PER FT.
WIND LOAD DIAGRAM
NOTE:-
THE MAGNITUDE AND THE CO-INCIDENT ACTION OF WIND FORCES IS OPEN TO SOME QUESTION.
FURTHER, THE POSSIBILITY OF SIMULTANEOUS MAXIMUM WIND AND MAXIMUM LINE LOAD IS DEBATABLE.
ALLOWANCE OF INCREASED UNIT STRESSES IS COMMON METHOD OF EVALUATION OF THIS FACTOR.

Figure 6 — In typical column design analysis, wind stress can be considered in two parts, roof wind and wind on the column proper.

restoring connecting force, R_t''', between the two columns (Figure 9). A valid solution has now been secured without ever losing the sense of logical, geometric action. The only simplifying assumption actually needed was that the ratio of the moment of inertia of roof truss to column top shaft should be considered infinite. Columns of varying stiffness, and multi-legged bents complicate the foregoing procedure only slightly.

As long as the basic principle of space-frame action is used, the authors hold no special brief for this method,

Figure 7—Simple calculation is required for the restoring moment at the top.


WIND ANALYSIS — ROOF WIND
NOTE; EACH COLUMN CARRIES EQUAL PROPORTION (IF COLS. ARE SAME)
ROOF WIND LOAD DIAG.
STEP 1 TOP CUT
STEP 2 APPLY RIGHTING MOMENT
MOMENT DIAGRAM ROOF WIND
638 IN.K
1812 IN.K
CALCULATE δ1 IN STEP 1
Mc = 5K x 142" = 710 IN.K
MB = 490 x 5 = 2450 IN.K
Mc/EIT = 710/E x 1355.1 = 0.524/E
Mc/EIB = 710/E x 11048.2 = 0.0642/E
MB/EIB = 2450/11048.2 = 0.222/E
X = 0.4598/E
δ1 = 0.4598/E x 142/2 = 32.55
0.222/E x 490/2 = 54.45
= 87.0/E
CALCULATE δ2 IN STEP 2
MT/EIT = MT/E x 1355.1 = 0.0007375 MT/E
MT/EIB = MT/E x 11048.2 = 0.0000905 MT/E
δ2 = 0.0007375 MT/E x 142" = 0.1049 MT/E
0.0000905 MT/E x 348" = 0.0315
= 0.1364 MT/E
EQUATE δ1 = δ2
0.1364 MT/E = 87.0/E
MT = 638 IN.K
MB = 490 x 5 = 2450
638
1812

should the designer prefer something other than the moment-area process. The original concept was developed using least work, and at least one other designer prefers the conjugate beam concept. Another design group has developed formulae solution for the problem which will, of course, yield identical answers. The important point is the basic concept of space-frame action. The tool is subject to the designer's choice.

At this point, it would seem auspicious to delve a bit into the realm of speculation. While for a specific geometry, it is easy enough to solve for the necessary moments and shears, it is evident that considerable latitude exists in the possible variations in ratio of "I" of the bottom shaft to "I" of the top shaft. It would seem entirely possible that this problem could be programmed for analog computer solution, and curves of base moments, bottom shaft moments, and top shaft moments could be produced for varying I_b/I_t ratios. This would result in a family of curves for a variety of ratios of bottom shaft length to top shaft length. When equipped with these curves, a designer could then select an optimum I_b/I_t ratio for his specific problem. Figure 10 shows two such sample curves made by conventional analysis (see Figure 11 also).

At this point, it might be well to comment on another practice of some designers. This practice utilizes a stub column section consisting usually of a wide flange directly under the crane load with axes parallel to runway. The back section of the column is continuous from foundation to roof truss with axis perpendicular to the axis of the runway. The theory of this application is that eccentricity is eliminated and the back shaft carries all of the side thrust loading. While the idea has merit in principle, in practice, it is difficult, if not impossible, to establish. The reason for this is that the top shaft must be tied together with the back shaft at the top and usually at intermediate points. Unless these ties are truly pinned, the practice cannot be substantiated because shortening of the front shaft under direct load will produce distortions in the combined system similar to, if not identical to, what they would be if the systems were effectively combined. In effect, a vierendeel truss set vertically is produced.

While the principal design problems of interest relate to crane girders and columns, certain other features are worthy of comment in mill building design. Foundation design, and particularly the sampling and testing processes that are required to furnish the designer with soil bearing or pile values have been discussed in a paper by George S. Richardson(4). Our practice has been to carry into the foundation all loads, including not only dead and live loads, but also impacts, side thrusts, shear and moments. At the same time, it is recognized that soil bearing values and pile loadings are relatively conservatively stated. In an attempt to evaluate this factor, a 50 per cent increase in soil bearing value and 33⅓ per cent increase in pile values for the most severe combination of all loads has generally been allowed. The reason for this practice is to secure a better balanced design.

The longitudinal stability of the structure is a feature which should always be investigated. Modern practice is to design structures for maximum length between expansion joints of about 400 ft. Experience has shown that structural distortions are likely to occur if excessive

lengths are used. One ideal practice is to make adjacent sections completely self-sufficient by using double columns and trusses. If this is not done, it is advisable to seat crane girders and other principal members on lubricated bronze plates to avoid freezing between steel surfaces. Longitudinal bracing has also undergone changes in recent years. Old-fashioned practice was to brace end bays and every fifth bay along the runway.

involved, the draft-gear type is, of course, indicated. The stopping force is usually based on the use of 50 per cent of the rated bridge speed and the length of travel of the spring of draft gear. Since this is usually a force of considerable magnitude and is centered at some height above the top of girder, it is generally impractical to bolt or rivet a bumper block to the top flange of the crane girder. The best practice instead is to run a pair

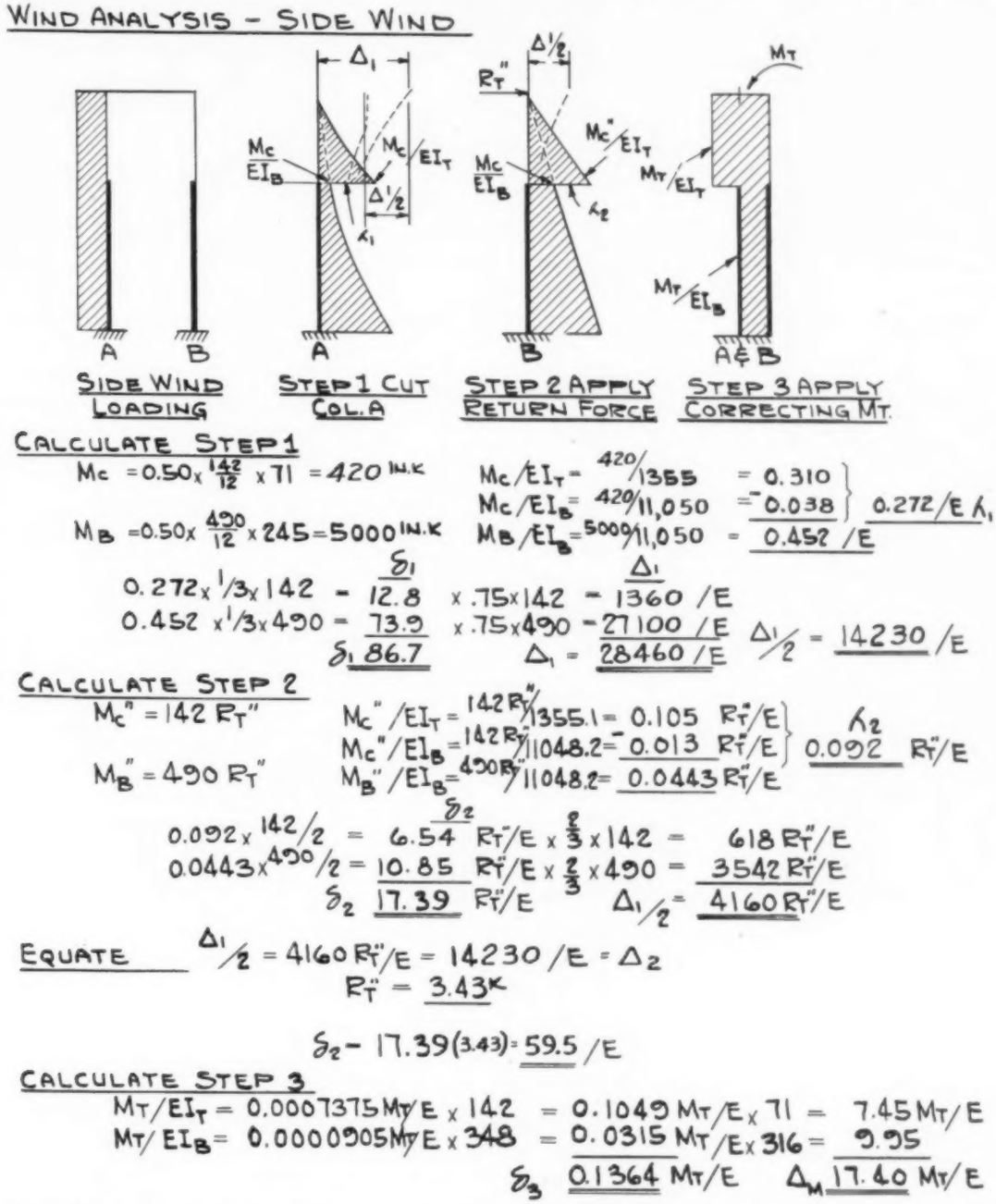


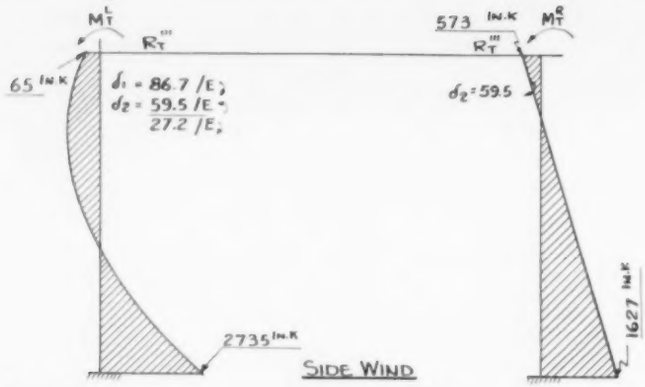
Figure 8 — Steps are given for analyzing the effect of the wind on the column proper

In one structure braced in this manner, the bracing in an end bay was cut during extreme weather conditions and the measured "spring" was 3/8 in. indicating that the contained forces were excessive. A little thought will show the fallacy of anchoring the ends of a structure against thermal movement. A better approach is to brace the center bay or center two bays and allow the structure to "breathe" thermally in both directions from the braced point.

Another matter of considerable interest is the subject of runway bumpers. These bumpers may be either spring or draft-gear type. When heavy cranes are

of heavy rods diagonally down from the force application point to the web of the girder. Through the use of adequate stiffeners, it is possible to make this arrangement completely safe and efficient.

An item of secondary interest but still of considerable importance is the method of attachment of the crane rail. In previous years, a constant maintenance problem was the tendency of the rail to open up at the joint, resulting in rough joints and ultimately broken rails. Modern practice varies, but both the thermit-welded rail and the tight-milled rail joint have proven satisfactory. It should be evident that the rail must be



EQUATION 1

$27.2/E = 0.136\, M_T^L/E + 17.39\, R_T'''/E$

EQUATION 2

$59.5 = 0.136\, M_T^R - 17.39\, R_T'''$

EQUATION 3

$17.39 M_T^L + 4160\, R_T''' = 17.39 M_T^R - 4160 R_T'''$

SOLVING SIMULTANEOUS EQUATIONS

$M_T^L = 65^{IN.K}$

$M_T^R = 573^{IN.K}$

$R_T''' = 1.06^K$

$\Sigma R = 3.43 \rightarrow$

$1.06 \rightarrow$

$4.49^K \rightarrow$

$M_B^L = 5000^{IN.K} - 4.49(490) - 65^{IN.K}$

$M_B^L = 2735^{IN.K}$

$M_B^R = 4.49(490) - 573^{IN.K}$

$M_B^R = 1627^{IN.K}$

Figure 9 — Computations next give the final restoring connecting forces between the two columns.

allowed to float freely longitudinally. Usually a two-bolt rail clip is used at about 18 to 24 in. on center allowing about ¼ in transverse movement each way from a centerline of rail. The ends are usually cut short of the end bumpers of the runway by several inches. Rails are usually run continuously across expansion joints. It is also worthy of mention here that the largest practical crane rail presently available is the 175-lb rail. The greatest load for which this rail is considered adequate is 110,000-lb wheel reaction. This establishes a practical maximum limit of crane wheel reaction.

Other miscellaneous matters which should be noted in passing as they concern mill building design are purlins, girts, and bracing. Jones & Laughlin has found that the junior beam sections make economical purlins and that girts of 5 or 6 in. channel are more efficient than angle girts. No rod bracing is used in the modern heavy mill structure, and all tension members are made to conform with the AISC 300 1/r limitation. Our practice has been to permit welding principally for repair purposes or for locations where impact does not exist. Where impact loads are important, the designer is cautioned that very conservative values for unit weld strengths should be used. Normal practice on ore bridge designs, for example, is to use about 50 per cent of the otherwise permitted welding stresses. Even this precaution may prove inadequate unless careful consideration is given to lock-in stresses, secondary stresses, notch effect and base metal annealing.

Both lighting and ventilation must be considered as integral parts of the complete mill building design. The most recent mill structures erected by our company are entirely without windows. This practice evolved as a result of the fact that practically all industrial processes are now three-shift operations. It is obviously short-sighted to provide day lighting for one shift and then require adequate artificial lighting for the other two shifts. The economical solution which omits entirely the maintenance cost of window-washing and the capital expenditure for sash—as well as access facilities for sash cleaning—is to omit the sash entirely.

This development has gone hand-in-hand with a

Figure 10 — Curves give data on eccentric moment at base of column with respect to various relationship between the top shaft and bottom shaft of the column.

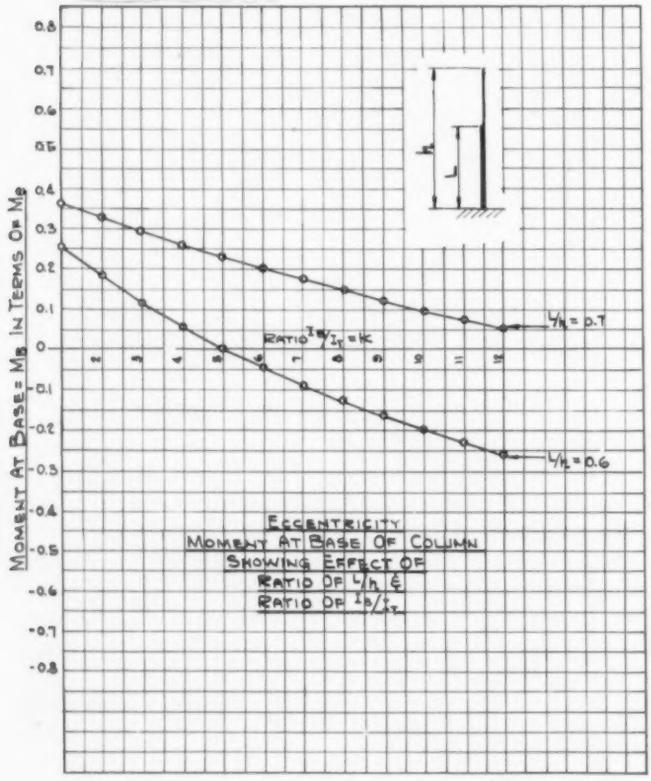


Figure 11 — General formulae for eccentric moment condition.

M_e = ECCENTRIC MOMENT APPLIED AT CRANE GIRDER SEAT.

I_T = MOMENT OF INERTIA TOP SECTION.

I_B = MOMENT OF INERTIA BOTTOM SECTION.

$I_B/I_T = K$ - RATIO OF MOMENTS OF INERTIA

h = DISTANCE FROM BASE PLATE TO HYPOTHETIC PIN.

L = DISTANCE FROM BASE PLATE TO CRANE GIRDER SEAT.

$M_e/EI_B = M_e/EIK$

$\Delta_1 = \frac{M_e}{EIK} \times L \times (h - \frac{L}{2}) = \frac{M_e L}{EIK}(h - \frac{L}{2})$

$M_C = R_T(h-L)$ $\quad \frac{M_C}{EI_T} = \frac{R_T}{EI}(h-L)$

$\frac{M_C}{EI_B} = \frac{R_T}{EIK}(h-L)$

$\delta = \frac{R_T}{EI}(h-L)(1-\frac{1}{K})$

$M_B = R_T \times h$ $\quad \frac{M_B}{EI_B} = \frac{R_T h}{EIK}$

$$\Delta_2 = \frac{\frac{R_T}{EI}(h-L)(1-\frac{1}{K}) \times (\frac{h-L}{2}) \times \frac{2}{3}(h-L) - \frac{R_T}{3EI}(h-L)^3(1-\frac{1}{K})}{\frac{R_T h}{EIK} \times \frac{h}{2} \times \frac{2h}{3} \qquad - \frac{R_T}{3EI} \times \frac{h^3}{K}}$$

$$= \frac{R_T}{3EIK}\left[h^3 + K(h-L)^3(1-\frac{1}{K})\right]$$

$\Delta_1 = \Delta_2$

$$\frac{MeL}{EIK}(h - \frac{L}{2}) = \frac{R_T}{3EIK}\left[h^3 + K(h-L)^3(1-\frac{1}{K})\right]$$

$$R_T = \frac{3MeL(h-\frac{L}{2})}{h^3 + K(h-L)^3(1-\frac{1}{K})}$$

$$M_B = R_T h - M_C = Me\left[\frac{3Lh(h-\frac{L}{2})}{h^3 + K(h-L)^3(1-\frac{1}{K})} - 1\right]$$

Figure 12 — View shows erection of columns and crane runway girders at J&L's new open hearth in Pittsburgh.

Figure 13 — Erection is further along in this view than that of Figure 12.

Figure 14 — This view is taken from the other end to that shown in the previous two figures.

gradual up-grading of the artificial lighting requirements. Where a mill structure erected twenty years ago was furnished with lighting that would provide 10 foot-candles at the working level, lighting intensities today are usually specified in the 15 to 20 foot-candle range. Increased reliability is required of mill lighting systems today, and the color-corrected mercury fluorescent lamp might have entirely replaced the incandescent fixture were it not for the time lag in re-lighting the mercury fluorescents after a power failure. For this reason, one-third to one-half of all the fixtures in a mill building are still required to be of the incandescent type, and these are distributed throughout the structure.

Careful study must be made of the heating and ventilating problem, particularly in buildings that house a process furnace. The dissipation of hot gases and noxious fumes in such a manner that the structure will not be damaged constitutes a problem of prime importance.

And finally, the skin of the building must be selected. While this is not related in the structural analysis, it may be a very significant point in the area of cost and life expectancy of the structure. Corrugated galvanized steel remains the commonest sheeting material. Protected metal sheets are widely used, as well as stainless steel, asbestos and aluminum. The ideal sheeting material would be weather-tight, corrosion-resistant, fireproof and economical. Some unfortunate results have obtained from fire hazards attributable to the relatively small quantity of combustibles contained in a sheet coating. The modern coating used in present-day sheeting, however, has been found by our own fire tests to be very satisfactory in this respect.

In summing up, it will be recognized that certain areas of disagreement will exist among various designers. Generally, these disagreements will revolve around points which relate to opinions that cannot be substantiated either way. Such questions as the magnitude and area of action and wind forces are still evaluated empirically. Another nebulous question is the likelihood of simultaneous maximum loadings from several cranes. While these points can be partially resolved by specification limitations, some policy latitude must necessarily remain. The engineer can obtain data on operational practice and then use some judgment in selecting conditions of loading. One point of extreme importance is that such decisions, when arrived at, should be clearly shown on both the calculations and the drawings.

The AISE has already done an outstanding piece of experimental work in the crane girder tests(1) that were the basis of the present specifications for electric overhead travelling cranes. It would seem to be a logical extension of our committee activity to extend this work into the field of model specifications for mill building design. Such a specification could very well serve as an industry-wide standard, and participating companies could adopt it with exceptions or deletions as they deemed appropriate, in a manner much like the crane specifications are presently used. Such a model specification could incorporate the best practices of many companies and the necessary testing and experimental work could be centralized and supervised by this AISE committee, with benefits accruing to the entire industry through a constantly rising standard of safety and economy in mill building design.

BIBLIOGRAPHY

1. "Report on Crane Girder Tests," by I. E. MADSEN, AISE Yearly Proceedings, 1941, p 593.
2. "Correct Crane Runway Design," by JAMES A. EVANS, AISE Yearly Proceedings, 1956.
3. "Flexible Connection Reduces Crane Runway Maintenance," by JAMES A. EVANS, AISE Yearly Proceedings, 1953, p 738.
4. "Foundation Design for Iron and Steel Plants," by GEORGE S. RICHARDSON, AISE Yearly Proceedings, 1954, p 257.

DISCUSSION

PRESENTED BY

I. E. MADSEN, Research and Standards Engineer, Association of Iron and Steel Engineers, Pittsburgh, Pa.

J. J. MURRAY, Development Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

JAMES EVANS, Registered Structural, Mechanical, Industrial Engineer, Massillon, Ohio

I. E. Madsen: We expect this paper to become a small bible and design manual to which many in the steel industry will refer, as they consider construction of mill buildings. The following comments apply specifically to the design of the crane girder and the crane runway girder only as affected by the crane. Unless crane runway is specifically mentioned, the crane girder itself is meant.

The first research and actual measured data on crane girder forces, loads, and stresses was a research program sponsored by the Association of Iron and Steel Engineers in 1939 and 1940. The results of this work provide the foundation for many of the clauses in the AISE specifications for electrical overhead cranes, AISE Standard No. 6, which has since been extensively adopted as a design manual, in both this and foreign countries, and outside the steel industry as well as within.

Several items which were new in these specifications were lateral forces, impact load approach, and the action of the girder under horizontal load. Since that time there have been several more extensive research investigations, particularly in England by the British Iron and Steel Research Association BISRA, and also by a similar group in Sweden.

The British work is available in the 1955 BISRA crane specifications for heavy duty EOT cranes for use in iron and steel works. The important point is that the factors for impact, lateral loading, and inertia forces correspond quite closely to those in the AISE specifications and thus checks the original work.

However, since the crane loadings and forces are such an important factor in the crane runway design, care must be applied in using them for the crane runway.

The total lateral force on the two crane runways due to the trolley forces reaches a maximum of about 20 per cent of the total load on the trolley. The question, which is still unknown, is how the forces are split between the two crane runway girders, since that is affected by variation in span, wheel taper and wheel flange action. A worse problem occurs when the trolley hits the rail stop.

The amount of impact on the runway girder is with one exception less than that on the crane. The crane tests, and stress measurements, showed that the further one gets from the point of impact load, the less impact effect is present, since the stretching of the cables, and spring or deflection in the crane girder and other structural members cushion and reduce the impact forces.

The one exception is impact due to such conditions as bumps or bad runway joints on the crane runway girder. Impact due to this cause is cushioned in the crane girder, but at a maximum on the crane *runway* girder. There crane impact forces may underestimate the severity of this factor, which may run up to 100 per cent or more.

We have heard that J. & L. in some of its crane runways have installed a rubber cushioning material under the crane runway rail. I would like to ask Mr. Murray if they have been able to determine if this has reduced impact forces. Is it possible to say if there has been any reduction in maintenance costs or problems because of the use of this cushioning material?

With reference to Mr. Murray's remarks on girder resistance to lateral forces, in the case of box girders, the whole section can be assumed to take the load because it resists twist so well. The tests prove this clearly. An I-beam does not resist twist as well and although the whole I-beam helps support lateral load, if twisting is present, the top flange deflects more and as a result is more highly stressed than the bottom flange.

To offset this, the top flange is commonly reinforced, although designing the section to resist twist by fixing the ends or using a welded girder will usually make the metal work more efficiently. In the case of a box girder, the web resists most of the horizontal load.

With reference to Mr. Murray's comments on the length width ratio of girders, the AISE specifications apply *only* to box girders. They were not intended for I-beam girders. Within these ratios no reduction factor need be applied to compressive stresses in the top flange, and for box girders the ratio is perfectly safe.

Before closing, I would like to mention that crane acceleration tests in steel plants are needed. Such data would be helpful in the design work discussed by Mr. Murray, since the loads can be easily computed from such data. The data would be even more important in establishing the sizes of motors for bridge and trolley drives.

All that would be necessary for such a test would be to attach a recorder on the drive to measure both speed or RPM and time. Acceleration is the most important load which sets the bridge drive size, but most people find it easier to think in terms of speed.

To point out how such data would help, I would like to cite the case in a recent plant who decided to order a crane for a particular mill which would work with several others on the same runway. However, after erection, there were complaints that the crane was underpowered and sluggish. A mill test showed that the crane met the specified acceleration, but the other existing cranes on the same runway were much better than assumed.

If a test had been made on one of the existing cranes before ordering the new crane, the crane builder would have designed the drive with no trouble since he would then have known the capabilities of the existing cranes.

The AISE would like anyone who can furnish such data to send it in to AISE headquarters for use in the

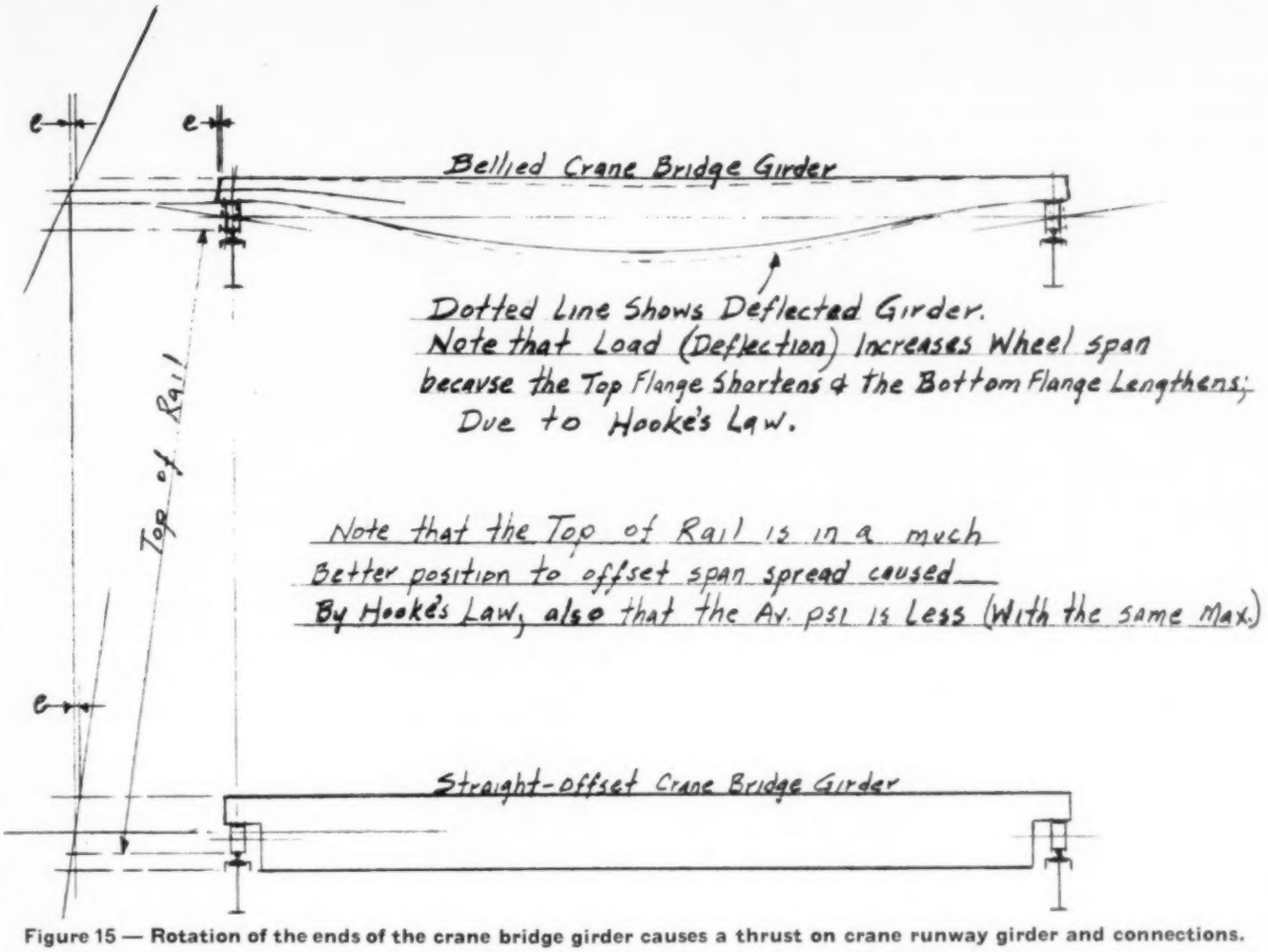

e
e
Bellied Crane Bridge Girder
Dotted Line Shows Deflected Girder.
Note that Load (Deflection) Increases Wheel span
because the Top Flange Shortens & the Bottom Flange Lengthens;
Due to Hooke's Law.
Top of Rail
Note that the Top of Rail is in a much
Better position to offset span spread caused
By Hooke's Law, also that the Av. psi is Less (With the same Max.)
e
Straight-offset Crane Bridge Girder

Figure 15 — Rotation of the ends of the crane bridge girder causes a thrust on crane runway girder and connections.

next revision of the crane specifications.

Much of the work which has been done recently on cranes is listed in the following bibliography:

BIBLIOGRAPHY

1. "BISRA Crane Specifications for Heavy Duty Electric Overhead Traveling Cranes for use in Iron and Steel Works," (rev. Sept. 1955) British Iron & Steel Research Assn., London, England.
2. "British Standard Report on Permissible Stresses in Crane Structures," BS2573:1955 British Standards Institution, 2 Park St., London W.1, Price 4/-net.
3. DIN 120—German Standards Publication 3029-1936—German Standards, 1936, Berlin.
4. "Dynamic Stresses in Electric Overhead Traveling Cranes Due to the Hoisting and Lowering of Loads," by E. Lightfoot and B. L. Clarkson, The Institute of Mechanical Engineers—Paper presented at General Meeting, London, England, 26 Nov. 1954, Published 1955, Vol. 169, No. 10.
5. "Dynamic Forces in Cranes," by J. Gotzlinger and Stig Johnsson, Acta Polytechnica, No. 175 (1955), Mechanical Engineering Series, Vol. 3, No. 6, Swedish Academy of Engineering Sciences.
6. "An Investigation of Fatigue Failures in Structural Members of Ore Bridges Under Service Loadings," by L. T. Wyly and M. B. Scott, AREA Bulletin 524, Sept.–Oct. 1955.
7. "A Technique for Measuring Stresses in Overhead Traveling Cranes," by H. Fealdman, Civil Engineering and Public Works Review, April and May, 1953.
8. "Girder Flange Design," by J. S. Terrington, British Iron and Steel Research Association, Restricted Report, April–May 1953, List No. 53.
9. "The Design of Crane Gantry Girders for Steelworks," by J. S. Terrington and J. M. Hawkes, British Iron and Steel Research Association, Restricted Report, April–May, 1953, List No. 53.
10. "Static Stresses in Electric Overhead Traveling Cranes," by E. Lightfoot and N. Jackson, The Structural Engineer, Jan., 1957.

Figure 16 — No diaphragm is used on this crane runway girder-column connection.

J. J. Murray: There is one question I would like to answer, and that is the result of our use of rubber on the rails. I am afraid I cannot give you a very good answer. I have a number of times suggested that I would like to have time and opportunity to apply some of these equipments we actually have. We have dynamic electric strain gage measuring equipment, including the necessary oscillographs, but unfortunately testing of that sort is time-consuming. The importance of getting more concrete data on these points of dynamic measurements we should stress, because there is very little of this sort of work done.

James Evans: I am very happy that a man of the author's knowledge and experience has taken an interest in this neglected stepchild, which is my particular subject. After many years of inspecting them, trying to find out a lasting way to repair them, I finally had an opportunity to use strain gages on a long open hearth crane runway that had been built starting in 1915, extending into 1916, 1918 and so on until it was 1200 to 1400 ft long.

I was rather amazed at the results of these. They did not check with my analysis, of course, but finally I reconciled myself to the fact that I was wrong—the strain gages were right.

Using these strain gages, however, taught me one thing, a very, very valuable thing. That is the importance of Hooke's law, that stress and strain are proportional within the elastic limit. The point I want to get across is that with the proper observance of Hooke's law one can eliminate 90 per cent of runway problems.

The deformation due to Hooke's law is directly proportional to the length and almost directly proportional to the average stress in that girder. No one can deny the fact that the crane wears out the runway. I wonder how many crane buyers know what points to look for to make sure it will be easy on the runway? See Figure 15. Normal practice allows only for the lateral thrust of the moving trolley, however in the longer spans (and under other conditions) this trolley thrust is far exceeded by the changing span spread caused by Hooke's Law.

Figure 16 is an installation of a one piece flexible crane runway to column connection of which one is required per column and no diaphragm is needed. This is one of five patented or pat. applied for designs. All five allow the girder top chord to float freely endwise. Additional information can be found in references (2) and (3) at the end of Mr. Murrays' paper.

1957 AISE

ANNUAL CONVENTION

SEPTEMBER 23, 24, 25, 26

PENN-SHERATON HOTEL

PITTSBURGH, PA.

By J. M. GRAUBARD, Supervisor of Design, Coke Plant, United States Steel Corp., Fairless Works, Fairless Hills, Pa.

Methods of Desulphurization of Coke Oven Gas

. . . . increasing demands are being placed on removing sulphur from coke oven gas . . . . these demands arise as sulphur content in coals increase, and as sulphur restrictions by the user become more rigid . . . . sulphur in compounds because of their tendency to increase corrosion also adds much to maintenance problems . . . .

▲ THE first known reference to the phenomenon of the carbonization of coal was made by the Greek philosopher Theophrastus, a pupil of Aristotle. In "History of Stones," dated about 371 B.C., he refers to the lepara stone becoming like pumice, when burning, changing both its color and density. Mention is also made during the middle ages of coke used by the silversmiths on the continent of Europe.

The earliest modern reference to coke is a recommendation for carbonization of coal made in 1584 by Duke Julius of Braunschweig-Luneberg, who operated the Hohenbuchen Mine in the Harz District of Germany. Around 1589, Procter, Peterson and Dudley tried to carbonize coal in England, and in 1590 an english patent was issued to John Thornborough to "purify pit coal and free it of its offensive smell." This first coking was accomplished in piles containing flues which were created by suitable arrangement of larger lumps of coal, or with pieces of wood. The piles were covered with earth or with wet coke breeze and then ignited. In the course of several days, coking was completed, the fire extinguished and the resulting coke dug out for use. See Figure 1.

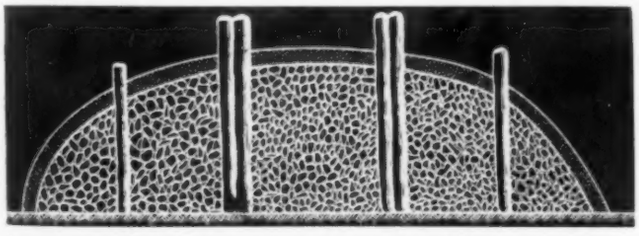


Figure 1 — First coke was made in piles with flues and having a special arrangement of large lumps of coal or wood.

Permanent flues and hearth structures for the piles gradually developed, and from these beginnings the beehive type ovens were developed about 1763 in England. About the time of the first beehive oven, the usefulness of the gas and tar, which were formed by heating coal, began to be recognized and efforts were made to produce these materials from coal.

FIRST BY-PRODUCT RECOVERY OVEN

It seems that the first very crude by-product ovens may have been built in 1766 near Saarbrucken, Germany. These ovens were intended to remove sulphur from coal so that the coal could be used in making iron, and also to save oil, tar, ammonia and soot. The venture ended in a complete failure.

Development of the ideas of the Saarbrucken ovens came very slowly. For almost one hundred years, the low market value of by-products, the poor quality of coke made, the crude design of equipment and the ample supply of tar and ammonia from gas works, held the growth of the by-product coke industry at practically a stand-still.

In the meantime the progress in the gas industry had been going ahead. In 1792, a successful process for the manufacture of gas was developed by William Murdock, and in 1802 his house and the plant of Boulton and Watt, in Birmingham, England were lighted by gas. These first gas retorts were inclined and were heated by burning coal in grates below them.

In 1812, the present Gas Light and Coke Company of London, England, was organized, and four years later in 1816, the first gas works (Figure 2) was built in the United States at Baltimore, Maryland.

The long stalemate in the by-product coke industry was broken in 1856 at Commentry, France, where Knab built a battery of by-product ovens and apparatus to recover gas, tar and ammonia. The gas was returned and burned in flues to assist in coking the coal. The most important advance made by this oven was in the coke yield which was 63 per cent of the coal charged. In 1862, Darves and Company added three horizontal heating flues in the walls while retaining the floor flues of the Knab oven, and used the first exhauster to suck the gas away.

In 1885, Louis Semet, chief engineer of the Brussels

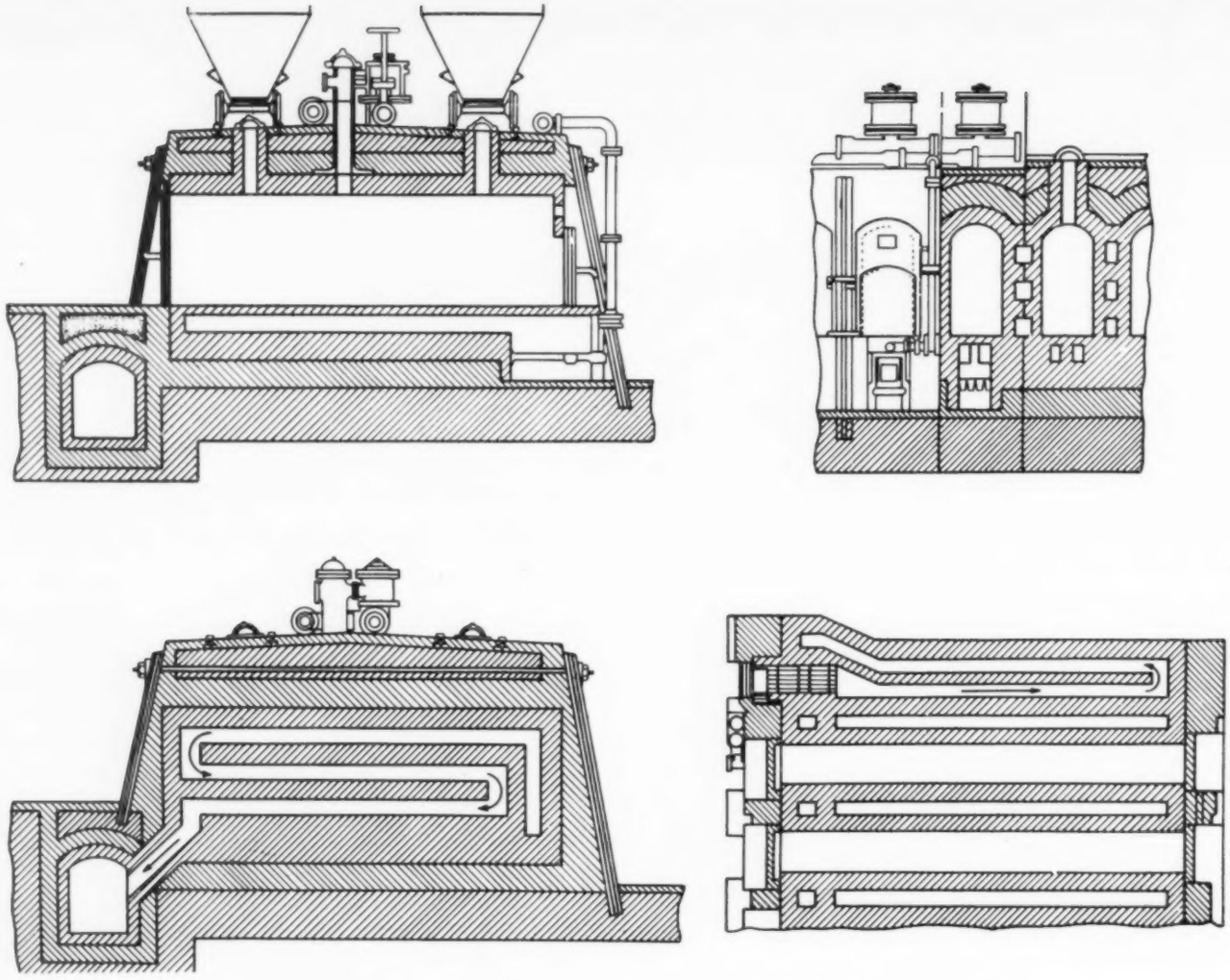


Figure 2 — Sketch shows first gas works plant in the United States in 1816.

Gas Works, and brother-in-law of Ernest Solvay, built 25 four-ton-by-product ovens at Havre Colliery, near Mons, Belgium. Semet became director of the Solvay Company and in 1892, he built the first by-product ovens in the United States at Syracuse, New York. This plant consisted of 12 ovens, 30 ft long by 6 ft 6-in. high. The maximum charge was 4.5 tons and the coking time was 36 hrs. Shortly thereafter, the suitability of by-product coke for blast furnace use was established and several organizations built successful ovens. In spite of the success of the early installations by Semet, Otto-Hoffman and Heinrich Koppers, the development of the by-product oven in the United States was slow. It was not until the war years of 1914 to 1919 that the demand for by-products for synthesis of dyes, which were no longer obtainable from Germany, together with a major expansion in the steel industry, led to a rapid increase in by-product coking. In 1919 the tonnage of coke produced in by-product coke ovens in the United States exceeded that produced in beehive ovens.

MODERN OVENS

Except during times of high business activity, less than ten per cent of the coal which is coked is carbonized in beehive ovens. It is interesting to note that some 800 beehives are being reconditioned at this time (Figure 3).

The by-product oven is one of the most elaborate and costly of masonry structures and must be erected with the closest attention to engineering details so that it can withstand the severe strains incurred in its use.

The ovens are long, narrow, silica brick chambers, in which the coal is coked by the combustion of fuel gas in flues built in the refractory brick walls which separate the ovens. Properly blended coals are charged into these coking chambers, where, by a process of destructive distillation, the volatile matter is drawn off as gas and the residue in the oven is coke.

GAS PROCESS IN COKE OVEN PLANT

During the coking period the gas is drawn off together with entrained liquid particles, passing upward from the ovens through a "goose-neck" into the collecting main. From this point on it is subjected to conditioning treatments for the removal or reduction of the concentration of the many compounds found in coke oven gas.

The gas treatment at the Fairless Works is typical for most modern plants. Tar and water are removed by condensation in the collecting mains and primary coolers. Tar can be used in the open hearth as fuel, or it can be sold or refined for various tar products.

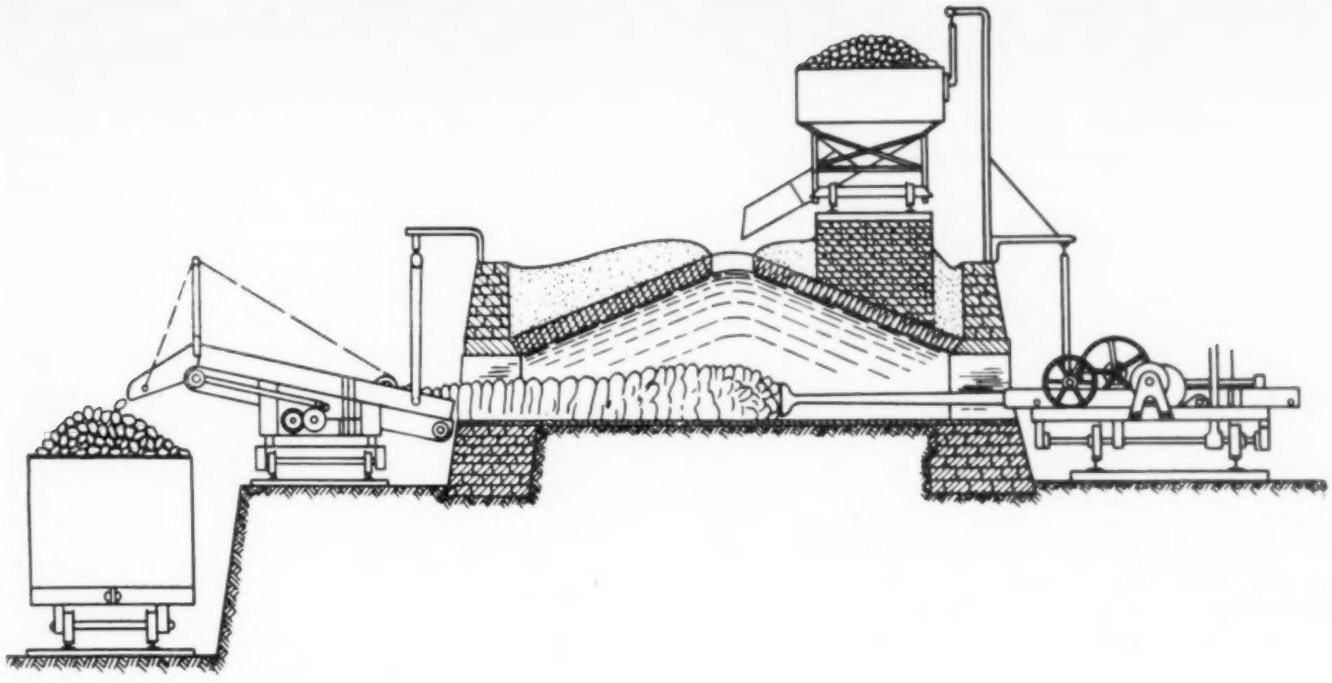


Figure 3 — Mechanization has been applied to the modern beehive oven.

Ammonia is next removed from the gas by a process of washing the gas with a dilute solution of sulphuric acid. Crystals of ammonium sulphate are built up in a controlled crystallization process to a desired size, removed, dried and sold to the fertilizer industry.

Further cooling of the gas in the "final cooler" condenses out naphthalene which is recovered and sold as such.

The various light oil constituents are next removed from the gas by absorption in a wash oil. These light oils are known as the B-T-X (Benzene, Toluene, Xylene) portions are stripped from the wash oil, separated and refined. They are used as the basic organic chemicals, solvents, dyes, etc.

The coke oven gas remaining is divided at this point, a portion of it going back to the ovens for underfiring. The rest being pressurized to 7 to 10 psig and distributed throughout the steel plant.

PLANT LOCATION OF DESULPHURIZATION PLANTS

Desulphurization equipment is normally placed in the system before the light oil scrubbers or after the mill gas boosters. The actual location depends on whether or not the total coke oven gas is to be treated or only the portion going to the open hearth or the total portion going to the mill. The exact location must be evaluated as part of the economics of a desulphurization plant.

It is not our purpose here to delve into the economics of the desulphurization process, this would best be done on an individual plant basis and would be highly affected by outside influences such as open hearth use of the coke oven gas, size of the by-product plant, the need for an assured source of sulphuric acid, the hydrogen sulphide content of the gas and many other variables particular to a specific plant and operation.

At present, the industry's reserves of the high grade coking coal with low sulphur content are becoming depleted, thus creating a problem for both coke and gas users. Part of this problem, so far as it is reflected by the high hydrogen-sulphide concentration can possibly be solved by gas purification.

Some 90 to 95 per cent of the sulphur found in coke oven gas is found in the form of hydrogen-sulphide. The remainder is commonly called "organic sulphur," primarily found in the form of carbon disulphide and thiophenes.

REASONS FOR DESULPHURIZATION

The presence of hydrogen-sulphide and other sulphur compounds in gas is objectionable for various reasons. Hydrogen-sulphide causes water to be corrosive, it is also corrosive to gas handling mains, and is the prime cause of deterioration to valves, tubing and mechanisms exposed to gas atmospheres such as meters, regulators, etc. The products of combustion of all sulphur compounds contain sulphur dioxide and sulphur trioxide, and these gases are corrosive and rather obnoxious in odor. For heating of open hearth furnaces and other furnaces for handling steels, excessive sulphur contents are of course undesirable, closer control of the furnaces being necessary with gases of higher sulphur content. The presence of sulphur compounds is undesirable also in the "bright annealing" of wire and similar products, the total sulphur in the gas being too great will cause an objectionable black scum to be formed on the surface of the metal.

EARLY PURIFICATION PROCESS

Very shortly after coal gas was first introduced for a domestic fuel, it became apparent that its sulphuric content was a decided disadvantage. Milk of lime was utilized for removing the sulphur compounds as early as

1809, just two years after gas was first introduced for street lighting. As one can well imagine, the equipment using milk of lime would become plugged with solid deposits and much trouble was encountered. The Milk of Lime process, however, was the first known gas purification process, and from the date of its introduction to the present time, there has been a continuous effort by gas industry people to develop processes more efficient, less expensive, requiring less labor and if possible, utilizing the sulphur removed from the gas at a profit.

In general, modern processes for the removal of hydrogen sulphide can be classified into two major groups, namely, the dry and liquid processes.

DRY DESULPHURIZATION PROCESSES

Use of iron oxide for the desulphurization of gas was developed by Laning and Hills and patented in 1849. About fifteen years later, lime purifiers in continental Europe were being replaced by iron oxide boxes and around 1890 iron oxide boxes began to appear in the United States. Methods for the chemical preparation of oxides have been steadily improved to yield better products and as a result, all types of iron oxide purifiers remain in use. The basic design of the oxide purifiers have not changed fundamentally since the early installations, however, with closer control and improvements in type of oxide, their capacities have been increased.

The classic dry iron oxide box method for combined hydrogen sulphide absorption and oxidation to elemental sulphur was developed for practical use in the 1860's and is still in general use. In this process, the gas is merely passed through the beds of a loose material such as wood shavings mixed with an active iron oxide. The solid oxide reacts with the hydrogen sulphide to produce ferric sulphide and water. Passage of the gas through the oxide is continued until some hydrogen sulphide is not absorbed and carries through in the outlet gas. The oxide is then regenerated by contact with air and can be used for purifying more gas.

The cycles of fouling and regenerating are continued until the activity of the oxide drops too low to justify further use. This is caused by tar deposits agglomerating the oxide particles and by the dilution of oxide by the sulphur deposits and loss of a portion of the iron which reacts with the cyanide in the gas and cannot be regenerated by exposure to the air and will not react with hydrogen sulphide.

F. W. Steere in 1919 developed what is known today as the Steere formula for the design of oxide boxes. The formula allows for the several variables required in the design of boxes and designates the proper "finagle factors" for the number of boxes in a set and for the grains of hydrogen sulphide per 100 cu ft found in the gas.

The conventional oxide box process, although simple and reliable in its operation, has disadvantages due to its large size, ground space requirement and the time and work required to change the oxide. Some attempts have been made to design equipment more compact and to provide continuous operation.

One modification in design of the equipment is known as the Thyssen-Lenz tower purifier and has found some use in a number of European gas plants. An installation using the Thyssen-Lenz principle consists of a number of tall circular towers, each tower containing a series of specially constructed baskets placed one on top of the other. The gas passes through the baskets containing purifying material and operates similar to the process of the conventional oxide boxes. The baskets are arranged so that the purifying material can be replaced in a shorter time.

Another type tower used porous briquettes of purifying material. The briquettes were removed from time to time from the bottom of the tower, the sulphur extracted and the fresh briquettes fed back to the top of the tower. This idea did not get further than the pilot plant stage.

Many other attempts were made using various purifying materials but the iron oxide box process seems to remain the most popular of the dry methods of recovery.

Liquid processes for the removal of hydrogen sulphide have been developed in an attempt to avoid the drawbacks of the dry processes.

LIQUID PROCESSES

Probably the earliest liquid process after the original milk of lime purifiers, was in 1880 when Hill and Claus attempted to use ammonia liquor as a removal agent and then heated the liquor to expel the hydrogen sulphide. Other early liquid processes, such as that of gluud, were based on the use of iron oxide and nickel oxide in alkaline suspensions for absorbing the hydrogen sulphide. The sulphur yielded from these processes was not of high purity and the entire systems were complicated by the presence of various cyanide compounds.

One of the first successful liquid purification processes is known as the Seaboard soda liquid purification process, and was first placed in operation on a plant scale in 1920. Because of the extreme simplicity and low operating cost, the process found wide favor in the gas industry. The gas is washed with a solution of sodium carbonate which, upon contact with the gas, forms sodium bisulphide and sodium bicarbonate. The fouled solution can then be actified by passing air through it, the hydrogen sulphide is carried off in the air and the sodium carbonate reformed and ready for purifying more gas.

In practice, the process is carried out by circulation the sodium carbonate solution continuously through a tower built in two sections: the absorber, in which gas is purified, usually above, and the actifier, below. Both sections are packed with wooden hurdles over which the solution flows. Actified solution is sprayed in at the top of the absorber, the fouled solution leaves the base of the absorber through a seal and flows by gravity into the top of the actifier. From the base of the actifier the solution is pumped back into the top of the absorber.

About three volumes of air per volume of gas purified are usually blown through the actifier by a fan. The volume of solution circulated depends to some extent on the degree of purification desired and on the concentrations of hydrogen sulphide in the gas.

In a single stage 85 to 95 per cent of the hydrogen sulphide can be removed from the gas, purification can be completed by means of an oxide catch box or a second seaboard absorber. The second stage absorber will in-

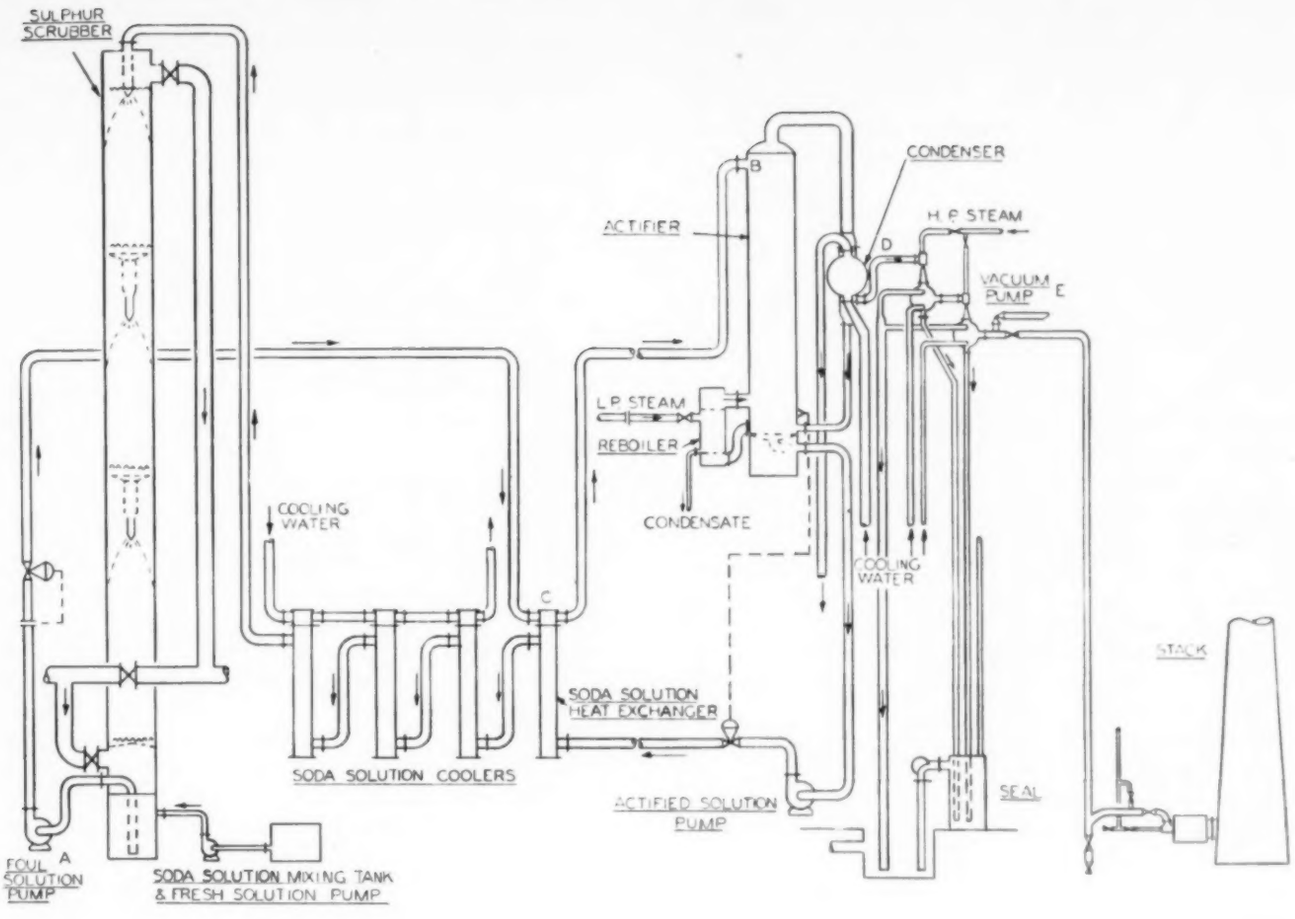


Figure 4 — Flow diagram for gas purification by hot actification process.

crease the recovery to as high as 97 to 98 per cent.

The Seaboard process is simple and requires a minimum of attention, but it must be remembered that the value of the process is based entirely on the removal of the hydrogen sulphide from the gas since the concentration of sulphur in the air from the actifier is too low for commercial recovery. The greatest limitation to the Seaboard process is the disposal of the hydrogen sulphide bearing air. In spite of the limitations, the process is the cheapest means of removing up to 95 per cent of the hydrogen sulphide from fuel gases where the expenditure for equipment for sulphur recovery is not justified and where a simple satisfactory method of disposal of the effluent air may be found.

The requirements of the recovery of hydrogen sulphide for the manufacture of sulphuric acid brought about the development of many processes including hot vacuum actification, thylox, ferrox, nickel sulphur, girbitol, phosphate, ammonia, phenolate and many other proposed processes some of which have not gone past experimental stages.

Many processes have been developed and some expanded on for the recovery of hydrogen sulphide from the manufactured gas as ammonium sulphate and crude sulphur, such as the gluud combination process, and the koppers gas process which was the forerunner of the better known thylox process.

Thylox process—The thylox sulphur recovery process uses the counter-current flow principle of liquid and gas to remove the hydrogen sulphide, the gas being scrubbed with a clear solution of sodium thio-arsenate dissolved in water.

The actification of the solution is effected in a thionizer where the foul solution meets a flow of compressed air. The air is finely dispersed in the column and oxidizes the thioarsenate salt to its original composition with the liberation of free sulphur. The sulphur which is collected as a sludge is filtered to remove excess liquor and then prepared for agricultural sprays or cast as crude sulphur.

The most popular of the liquid processes today is the hot actification sulphur recovery process.

Hot actification process—In this process, steam is used as the desorbing or actifying agent in the contact tower in place of the air used for the same purpose in the Seaboard process. See Figure 4.

The solution can be actified under atmospheric pressure or under a partial vacuum, the use of a partial vaccum decreasing the steam demand by as much as 85 per cent.

The general principles of the Seaboard process and the vacuum carbonate process are similar, both being absorption-desorption processes, the prime differences between the two are, first, the steam at a reduced pressure is the desorbing vapor instead of air, and this steam is generated by boiling the liquid in the base of the actifier: second, condensers are placed at the vapor lines leaving the actifier to condense the steam and separate it from the hydrogen sulphide; third, a vacuum pump is operated to maintain the desired vacuum and to de-

liver the recovered hydrogen sulfide to the utilization equipment; fourth, actification occurs at high temperature and coolers are required on the actified solution; fifth, hydrocyanic acid is recovered with the hydrogen sulphide and sixth, oxidation to form thiosulphate and thiocyanate does not occur.

The principal equipment comprising a hot actification purification plant are:

1. *Sulphur Scrubber*—Where the soda solution removes the hydrogen sulphide from the gas.
2. *Actifier*—Where the hydrogen sulphide is released from the solution and the foul solution is actified.
3. *Reboiler*—Where vapor is generated from the soda solution, for releasing hydrogen sulphide from the solution in the actifier.
4. *Condenser After Actifier*—Where most of the water vapor is condensed out from the vapors leaving the actifier.
5. *Steam Jet Vacuum Pump*—Which maintains a vacuum in the actifier, and discharges hydrogen sulphide to the furnace or to process.
6. *Soda Solution Heat Exchanger*—Where the actified soda solution leaving the actifier transfers some of its heat to the foul solution entering the actifier.
7. *Soda Solution Cooler*—Where the actified solution is cooled before it returns to the solution in circulation.

Briefly running through the flow of the process, the foul solution is pumped continuously from the bottom of the absorber or scrubber through the soda solution heat exchanger where it is heated by the solution leaving the actifier, and enters the actifier near the top. The descending solution in the actifier passes over trays and is stripped of hydrogen sulphide by the vapors generated in the reboiler. Good actification is essential for obtaining maximum removal of hydrogen sulphide from the gas and good actification depends on maintaining a high vacuum in the actifier. The vapors leaving the actifier pass through a condenser and coolers to remove a majority of the steam. The actified and cooled soda solution enters the top of the scrubber through spray compartments against the ascending gas, the major portion of the hydrogen sulphide in the gas reacting with, and dissolving into the solution. The cycle then repeats itself.

The resulting gases from the actifier pass through the vacuum pump and are ready for further processing.

The hydrogen sulphide from the actifier is accompanied by a small amount of ammonia left in the gas from the absorbers, most of the hydrogen cyanide, and some of the carbon dioxide from the gas.

When the hydrogen sulphide is used for the production of sulphuric acid by the contact process, serious corrosion troubles will be encountered, probably caused by the combustion products of the ammonia and cyanide. The difficulties can be eliminated by compressing the vapors from the actifier and washing them in a scrubber with fresh water. Substantially all the cyanide and ammonia will be removed. The small amounts of hydrogen sulphide and carbon dioxide dissolved in the scrubber can be removed from the cyanide solution in a stripping column.

The hydrogen cyanide can either be sprung from solution by the desulphurized coke oven gas and burned at the ovens, distilled and absorbed in sodium hydroxide to produce concentrated sodium cyanide or scrubbed with soda as to form ammonia thiocyanate which is basically a weed killer.

For those interested in more actual operating details of the hot vacuum actification process, an excellent paper on the subject was presented before the American Coke & Coal Chemicals Institute, May 16, 1955, by J. K. Kurtz, superintendent of the Coke & Coal Chemical Plant at the Sparrows Point of Bethlehem Steel.

The adoption of the hot actification process eliminates the limitations found in the Seaboard process, in view of the fact that the sulphur recovered as hydrogen sulphide is available for manufacture of sulphuric acid; the side reactions are eliminated because of the lack of oxygen in the actifier, the hydrocyanic acid passes through without reaction and is recovered with hydrogen sulphide and the seaboard process problem or disposal is eliminated since the hydrogen sulphide is recovered for use.

The various processes that employ steam for actifying the solution used to absorb hydrogen sulphide from gas, recover gaseous hydrogen sulphide product. The recovered product can be utilized as: (1) hydrogen sulphide as such, (2) as sulphuric acid, or (3) as elemental sulphur.

The use of hydrogen sulphide as such is restricted by the fact that it must be compressed in steel cylinders for shipment. Some study has been made regarding the application of hydrogen sulphide in agriculture as fungicide, at the present, however, the use of hydrogen sulphide as such is limited.

Recovery of hydrogen sulphide for the manufacture of sulphuric acid can be accomplished in a contact acid plant.

MANUFACTURING SULPHURIC ACID

This type of acid plant for the manufacture of sulphuric acid from hydrogen sulphide was developed by Phillips, an Englishman, in 1831, however, the first plant did not show up in the United States until after 1900. By that time the method had become important in Europe for the manufacture of high strength acid needed in the dye industry. By 1930 the Contact process had been proven in the United States and is now in general use. About 1940, the Lurgi people in Germany developed a wet process plant for the production of 60°Be sulphuric acid from hydrogen sulphide at a lower initial and operating cost than the conventional systems. About 40 plants have been erected in Europe with capacities ranging from 5 to 30 tons.

SUMMARY

Interest in removal of sulphur from coke oven gas for industrial use is increasing, owing both to the increasing concentrations in the gas from the higher sulphur coals and to recognition of the benefits which result in many manufacturing processes from the use of low sulphur gas. As far as the by-product coke ovens serving the steel industry are concerned, the best process is one that will not only purify the gas as much as necessary for mill purposes, but also recover the sulphur for use in the plant and mill together with any other useful by-products which may be sold at a profit.

DISCUSSION

PRESENTED BY

W. H. COLLISON, Plant Superintendent, Blast Furnaces and Coke Works, Great Lakes Steel Corp., Ecorse, Detroit, Mich.

DWIGHT K. TAYLOR, Western Division Manager, Connelly, Inc., Chicago, Ill.

DONALD C. COLEMAN, Superintendent Coke and Coal Chemical Works, United States Steel Corp., Fairless Works, Fairless Hills, Pa.

W. H. Collison: At Great Lakes, with low sulphur coals, the sulphur content of coke oven gas is not high, about 385 gr H_2S per hundred cu ft. After purification and after mixing with blast furnace gas to 385 Btu, the gas delivered to the mill will average about 90 gr H_2S. This results from gas of 150 gr H_2S content being mixed sixty per cent coke oven gas and forty per cent blast furnace. This has been acceptable to the mill. With the completion of a fourth battery of coke ovens, straight coke oven gas will be pumped to mill and the 150 gr level may not be satisfactory.

Two desulphurization processes are operated, one in old coke plant, the other in new. The old plant, with the weak liquor system of recovering ammonia, is particularly fitted to the ammonia liquor process of desulphurization and that process is used. The new plant has the soda ash process with hot actification, with a flow sheet very similar to the one presented by the author. By-product sulphur is not recovered, the only aim being to make a gas suitable for the mill.

Since Great Lakes is located in an urban area with several sources of hydrogen sulphide, including ground water from a certain stratum, it is necessary to burn the hydrogen sulphide gas. In the old plant, an aluminum pipe carries it to the blast furnace gas main for underfiring the ovens. In the new plant it is burned in a Dutch oven at the base of the stack, with coke gas pilot light.

Both processes have operated satisfactorily, but are limited to about 70 per cent removal. Maintenance experience on the soda ash system is too limited to draw conclusions. The ammonia liquor system has shown conclusively that heavier cast aluminum is necessary in the actifier column, instead of lighter aluminum plate.

Dwight K. Taylor: Our business is the manufacture of the material that goes into the dry boxes, so everything that I say is prejudiced and you must remember this point of view when considering my remarks.

I would like to make one or two comments. Not only are steel men getting extremely quality-conscious, but they are studying every subject which in any way will affect quality.

The bright annealing of steel is a subject you are all working on. In many places the sulphur content in the atmosphere gas is recognized as a "little red devil" that causes a lot of trouble, so you want to get rid of it.

I feel the Seaboard process is the best for large volume work, but in order to get the last five or ten per cent of H_2S out you must double the size of the plant. It is one of those curves that comes down and goes out almost asymtotic to the axis. So you can take 90 per cent—and some people say you can take out 92 per cent—but if the last bit of H_2S is going to cause trouble, you have to use an oxide catch box to remove it. If such a box is operated properly you come out with a gas having less than 0.01 gr of sulphur. You have been told for many years that it could be below a quarter of a grain, but no one knew how low it was until a few years ago the Bureau of Mines laboratory in West Virginia developed a new methylene blue test for the careful analysis of very small amounts of H_2S in gas. So we can now tell what the oxide will really do.

In 1874 our company was started but we have really found out more about how to make a good material and how to operate it in the last ten years than we did in all that previous time.

One thing we must do is to make an economic study. The quantity of gas to be purified is a great factor. We believe that the oxide process can be proved more economical, if the amount of gas to be treated is below 20,000,000 cu ft per day, principally because investment costs have gone up so fast. Yes, labor and operating costs have gone up, too, but investment costs have gone up more.

This recent development of the vacuum process, as combined with the Seaboard, is a good one. It really revolutionizes the process. However, if you have below about ten tons of sulphur per day, it is not economical to make sulphuric acid because your investment in sulphuric acid manufacturing equipment is too great. If you put the hydrogen sulphide through a furnace and up a stack as he mentioned, it immediately changes it over to SO_2, so it goes out in the neighborhood. So you build a stack 200 ft high and hope it will blow away.

There is one other little point I must mention. The Steere formula which was developed around the early 1920's was the first real engineering way to calculate the right size of the purifier, but since that time the capacity of the material—of our competitors' as well as ours—has been tripled, and therefore the Steere formula produces a purifier box which is about three times bigger than it needs to be today. If anyone has problems on purifier design, either we or our competitors will be only too glad to give you the up-to-the minute capacity information.

Donald C. Coleman. The various methods by which sulphur is removed from coke oven gas, is however, not the real problem as far as the coke plant operator is concerned. As he has pointed out, we can remove the sulphur from the gas up to 100 per cent, but in order to install such a process it is necessary to justify its cost. It is very easy for a steel mill operator to say "we want gas with no sulphur" but when the coke plant operator tries to justify a plant to satisfy that demand he has to put a dollar value on the resultant additional cost.

If it is necessary to desulphurize the gas down to any point, or to zero, then the persons who expect to use that gas are the ones who should justify the additional cost. Therefore, I would like to have steelmakers really think about this question seriously, because they are the ones who should put the dollar value on the sulphur removal. If you cannot justify it neither can the coke plant operator.

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, March 25, 1957—Dinner 6:30 P.M., Meeting 8:00 P.M.

"**Trends in Electrification and Automation of Steel Plant Processes,**" by William E. Miller, Manager of Steel Mill Systems, Application Engineering Section, General Electric Co., Schenectady, N. Y.

Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, March 12, 1957—Dinner 6:30 P.M., Meeting 8:00 P.M.

"**The Forming of Flanged and Dished Heads,**" by Harry S. Beers Superintendent Flanging Dept., The Colorado Fuel and Iron Corp., Claymont, Del.

Hotel Sheraton, 715 Delaware Avenue, Buffalo, N. Y.

CHICAGO SECTION

Tuesday, March 5, 1957—Dinner 6:30 P.M., Meeting 7:30 P.M.

"**Effect of Industrial Developments in the Calumet Area on Power Requirements,**" by R. M. Schahfer, Chief Engineer and Vice-President, Northern Indiana Public Service Co., Hammond, Ind.

Phil Smidt's Restaurant, 1205 North Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Tuesday, March 19, 1957—Dinner 6:30 P.M., Meeting 8:00 P.M.

"**History and Development of the Cuyahoga River,**" by Harry Hobart, Department of Port Control, City of Cleveland, Cleveland, Ohio

The University Club, 3813 Euclid Avenue, Cleveland, Ohio

DETROIT SECTION

Tuesday, March 12, 1957—Dinner 6:30 P.M., Meeting 8:00 P.M.

Great Lakes Steel Night

"**Desulphurization of Blast Furnace Iron,**" by B. G. Gray, Air Reduction Co., Chicago, Ill.

Dearborn Inn, 20301 Oakwood Blvd., Dearborn, Mich.

LOS ANGELES SECTION

Data not available

PHILADELPHIA SECTION

Saturday, March 2, 1957—Dinner 6:00 P.M., Meeting 7:00 P.M.

"**Fuels Contribution to an Increase in Open Hearth Capacity,**" by C. W. Dunn, Superintendent Utilities Dept., United Steel Corp., Fairless Works, Fairless Hills, Pa.

"**Extended Hearth Increases Furnace Capacity,**" by Charles D. Guth, Furnace Design Engineer, Lukens Steel Co., Coatesville, Pa.

"**Increasing the Capacity of Old Open Hearth Shops,**" by M. K Morris, Assistant Superintendent No. 2 and No. 4 Open Hearths, Bethlehem Steel Co., Bethlehem, Pa.

Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.

PITTSBURGH SECTION

Monday, March 11, 1957—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Rolling Mill Slipper Symposium

"**Problem,**" by Alex Montgomery, Jr., Assistant to Vice-President—Rolling, United States Steel Corp., Pittsburgh, Pa.

"**Maintenance,**" by Frank O. Phillips, Assistant to Vice-President—Steel Maintenance Planning, United States Steel Corp., Pittsburgh, Pa.

"**An Application,**" by A. B. Millman, Superintendent of Maintenance, Jones & Laughlin Steel Corp., Aliquippa, Pa.

"**Design,**" by F. J. Gleve, Assistant Chief Engineer, United Engineering and Foundry Co., Pittsburgh, Pa.

"**Materials,**" by R. J. Severson, Assistant General Sales Manager, Ampco Metal, Inc., Milwaukee, Wis.

University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Wednesday, March 27, 1957—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"**Advanced Methods of Coil Construction and Motor Winding Practices,**" by D. E. Stafford, Chief Engineer, National Electric Coil Co., Columbus, Ohio

Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

Tuesday, March 19, 1957—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Kaiser Steel Corporation Night

"**Nuclear Energy in the Steel Mill,**" by P. J. Selak, Acting Division Manager, Nuclear Engineering, Kaiser Engineers, Inc., Oakland, Calif.

Shattuck Hotel, Durant and Shattuck Streets, Berkeley, Calif.

UTAH SECTION

Monday, March 11, 1957—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

"**Application of Speed Regulators for Hot Strip Finishing Mills,**" by L. E. Ringger, General Supervisor, Electrical Engineering, and G. S. Koss, Assistant General Superintendent Rolling Mills, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

Skylinker Cafe, Provo, Utah

YOUNGSTOWN SECTION

Monday, March 25, 1957—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"**The Problem of Water Conservation and Stream Pollution in the Steel Industry,**" by John E. Kennedy, Sanitary Engineering Consultant, Ann Arbor, Mich.

Mahoning Country Club, Girard, Ohio

Four Open Hearth Furnaces designed by Rust for Lone Star Steel Company's modern steel mill at Lone Star, Texas

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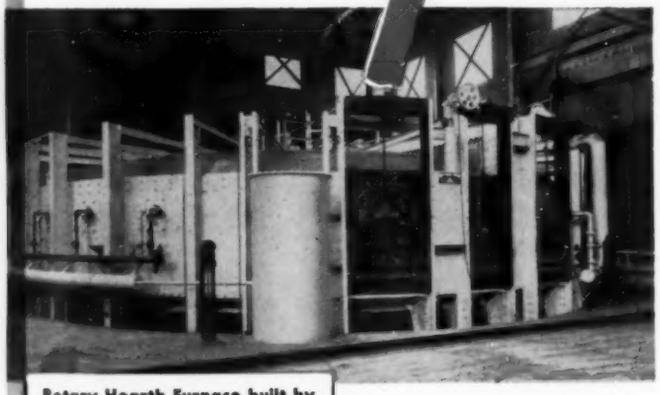

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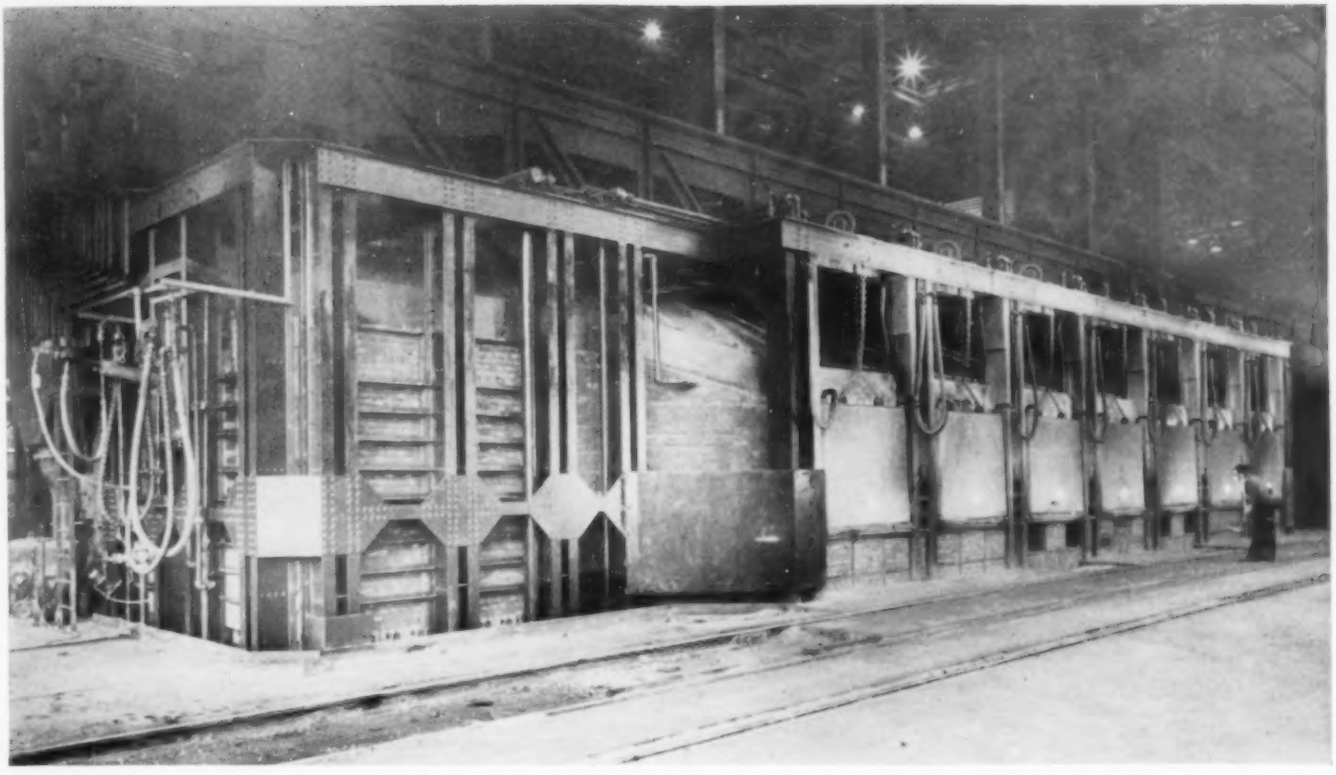

Figure 1 — New furnace has a rated capacity of 600 tons. New Production records are expected from the unit.

Weirton Steel Puts New 600-Ton Open Hearth in Operation

▲What is believed to be the largest open hearth furnace in the world was tapped Saturday, December 22, 1956, by the Weirton Steel Co., Division of the National Steel Corp. at Weirton, West Va. This furnace was designed and built by Loftus Engineering Corp., Pittsburgh, Pa. With a rated capacity of 600 tons, this furnace will be the fourteenth and largest open hearth to be installed in Weirton Steel's open hearth shop which is one of the highest producing single open hearth shops in the world.

To house the new furnace it was necessary to construct a 126-ft addition to the open hearth building which now has overall dimensions of 3120 ft by 190 ft.

The new furnace incorporates the most modern engineering features in design, automatic controls and auxiliary facilities. The furnace is a rectangular brick and steel structure with outer wall dimensions of 26 ft, 9 in. in width and 108 ft, 6 in. in length. The hearth area is 1485 sq ft. Bath dimensions are 18 ft, 6 in. in width by 75 ft in length with a depth tapering to the maximum of 3 ft, 7½ in. at the center.

The No. 14 furnace has seven charging doors compared with five doors in most smaller furnaces. Designed for a scrap and hot metal charge, the water-cooled doors are each six ft wide by more than five ft high above the sill line. The doors are so spaced that front flushing may be done on two doors simultaneously. These doors, together with special water-cooled reversing valves and dampers, are among the largest pieces of water-cooled equipment ever fabricated for this purpose. It can be fired with oil or tar. Provision has been made for the use of oxygen as an aid to combustion. Area of the checker heating surface is 38,600 sq ft with an input of 150,000,000 Btu per hr. Air enters the furnace's hearth area through two uptakes, each of which have dimensions of 8 ft, 6 in. by 11 ft, 6 in. The furnace ends are of the suspended basic brick type.

After the waste gases pass through the furnace, there is still a considerable amount of sensible heat left that is utilized in a double drum, water tube, waste heat boiler, having a capacity in excess of 30,000 lb of steam per hr at 225 psi. The waste gases are then vented through a self-supporting steel stack that has a minimum inside diameter of ten ft with a height of 250 ft. The waste heat boiler is equipped with automatic sequential soot blowers that force the soot into the furnace flue system where it is picked up with checker and flue dust by two soot

elevators that lift it for direct discharge into side-dump railway cars for disposal.

Actual construction of the furnace was accomplished in the remarkably short time of less than a year, despite serious setbacks in the delivery dates on the structural steel and plate required for the project.

At the same time that the building extension, with craneway, was being erected overhead, construction of the furnace, together with auxiliary equipment was performed by Loftus Engineering Corp. without interfering with operations of the steel company. The charging floor and tracks were supported by means of a sturdy system of temporary piling and bracing, while the contractor was installing substantial substructures and foundations.

It is expected that this furnace may well shatter production records and its performance will be watched closely by the industry.

Figure 2 — First tap on new open hearth was made on December 22.

Central Station Relining Unit Cuts OH Door Costs at Gary

▲A central station for relining open hearth furnace doors, set up in early 1953 at the Gary Steel Works of United States Steel Corp., has led to a substantial increase in door lining life and has contributed to greater steel production.

The average number of heats per door lining, for 50 furnaces in four open hearth shops, is now approximately 35 per cent greater than it was when the program began. Because of this consistent and substantial increase in door lining life, the average number of doors lined per month has decreased proportionately with a resultant saving in door lining material and labor costs. Fewer door changes have resulted in less furnace fuel-off time and have reduced the work load on charging floor cranes. These have been important factors in increased steel production rates.

The central door relining station was established at the Gary Works primarily because the individual shops—three with 14 furnaces, one with eight furnaces—seemed unable to keep up with demand for doors. Life of linings was erratic. The constant pressure for doors was leading to ill-advised shortcuts, such as failure to clean doors properly before relining, inadequate venting of the lining, and insufficient drying time. Relining operations were handicapped by insufficient preparation space, inadequate crane service, and lack of close supervision.

The control and uniform practice of the present arrangement enable the relining station to turn out from eight to ten doors a day with a crew of six men on a single shift. The station, under the supervision of the open hearth maintenance department, is located in an area equipped with an overhead traveling crane, used to move doors quickly and easily. With the exception of the gang leader, the men on the crew rotate job assignments informally. Crew size is often increased or decreased with any substantial change in demand for doors.

The work cycle at the central station starts when doors removed from furnaces for relining are placed in

TABLE I

Door Lining Life—Heats per Lining

Shop	1954 Fourth Quarter	1955 First Quarter	1955 Second Quarter	1955 Third Quarter	1955 Fourth Quarter	1956 First Quarter	1956 Second Quarter	1956 Third Quarter
No. 1 OH	67	81	93	92	83	103	105	95
No. 3 OH	77	79	92	95	97	97	93	97
No. 4 OH	73	76	90	94	95	89	106	106
No. 5 OH	98	96	105	129	130	128	120	136
Average	78	82	94	99	97	102	104	107

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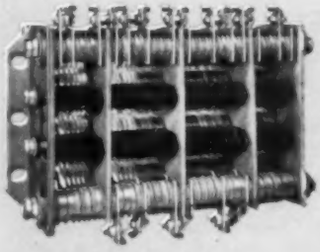

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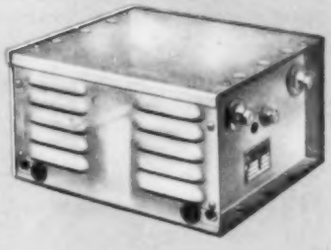

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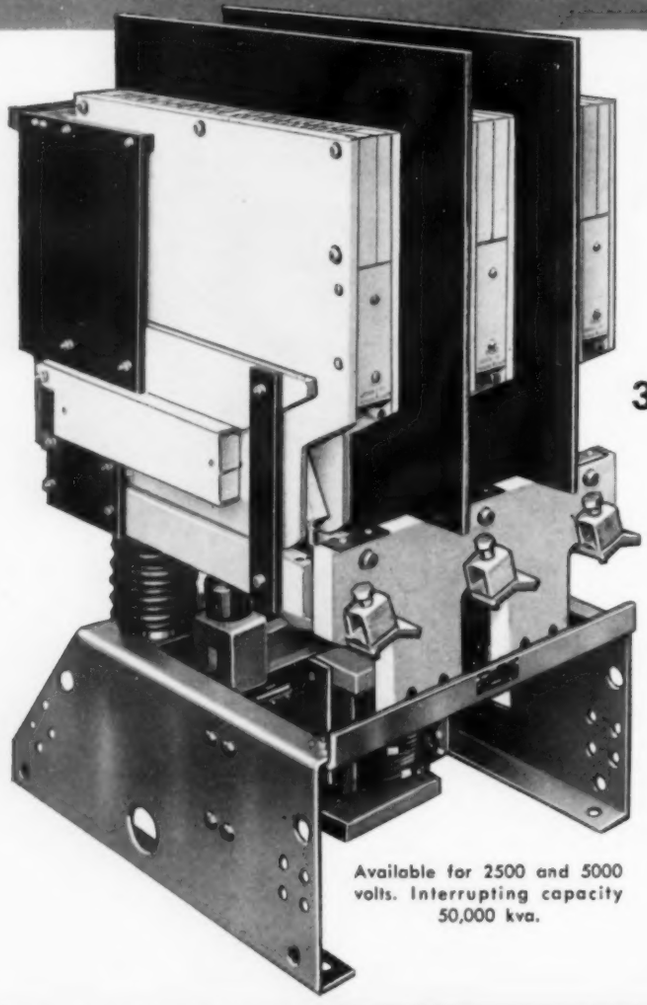

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NOTE THESE FEATURES—

- **ONLY ONE MOVING PART**—Simple solenoid design eliminates all pins, pivots, and flexible "jumpers."
- **COMPACT**—Unique design and development in new materials made possible a switch of unusually small size.
- **DOUBLE BREAK, SILVER ALLOY CONTACTS**—Require no maintenance. There are no flexible jumpers. Straight up-and-down motion assures good uniform contact pressures.
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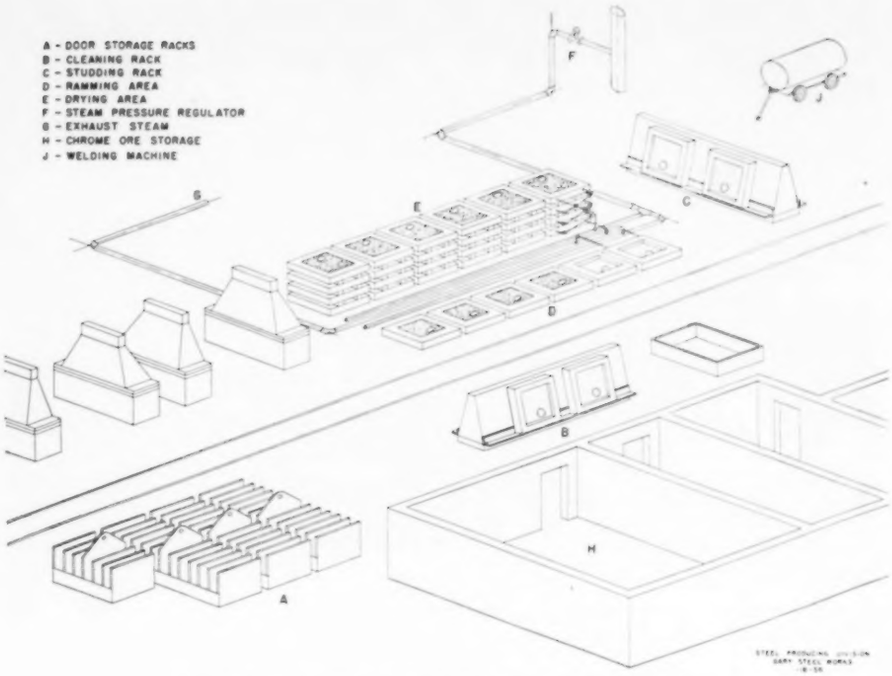

A - DOOR STORAGE RACKS
B - CLEANING RACK
C - STUDDING RACK
D - RAMMING AREA
E - DRYING AREA
F - STEAM PRESSURE REGULATOR
G - EXHAUST STEAM
H - CHROME ORE STORAGE
J - WELDING MACHINE

Figure 1 — Layout of central door relining station.

portable racks of 12-door capacity. When racks are full, they are carried to the relining station on skull cars pulled by engines. Sufficient space is available at the relining station for one rack from each shop. Doors are then put on cleaning stands which support doors at an angle of about 75 degrees. The old chrome ore refractory lining is chipped off with a compressed air tool. Old studs, used to support the lining, are burned off flush with the lining plate, with an oxyacetylene torch. The doors are then moved to the studding stand, which is very similar to the cleaning stand, and Nelson studs are end welded to the doors.

The studs perform two functions on the monolithic-lined doors. In addition to giving physical support to the lining, so that it will not fall out or slump to the bottom of the door, the studs serve as a heat transfer medium, conducting heat through the lining plate to the cooling water.

Originally, doors were laid flat for studding. It was discovered, however, that the stud welding operator does not tire as easily, and therefore welds more studs, when doors are worked on in an upright position.

Most of the Nelson studs used are ½ in. in diameter and 4½ in. long, with 280 studs on 3-in. centers being used on a standard door. However, since a ¾-in.-diam stud has a cross-section area 2¼ times greater than that of a ½ in. stud, experiments are being conducted with the larger size.

Studded doors are laid flat and connected to a steam manifold to check for leaks. The plastic chrome ore, stored in standard 200-lb containers in an adjacent room, is then shoveled into the doors, worked between the studs and finally rammed with a pneumatic tamper. Two complete passes of the tamper over the surface usually produce maximum density. The lining is then vented with a home-made tool with five ¼-in. diam prongs on 2½-in. centers.

Doors are stacked four high for drying. A steam manifold extends the length of the drying line, with door inlets and outlets connected, so as to allow steam to enter the top door and be exhausted through the bottom door. Drying time is at least 48 hours.

Experience at the Gary Works has shown that steam entering the doors should have a temperature of at least 275 F if the linings are to dry properly. In turn, proper drying has been shown to be very important in lengthening door lining life. (Actually, steam temperatures as high as 475 to 525 F are recommended, if available.)

After being dried for 48 hours, the door lining is tested by tapping it with a hammer. If a ringing sound results, the lining is considered dry. If the hammer produces a dull thud, the inner portion of the lining is considered still moist and the door stays on the drying line.

Accurate records of door lining life have been kept since shortly after the central relining station program was set up. Each time a door is relined, the gang leader marks down the blend of chrome ore, the door size, the type of door and type of studs. Records also are kept of the date each door was purchased and the date it was scrapped. Lining life is summarized each quarter.

Figure 2 (left) — Approximately 280 studs, ½ in. in diameter and 4½ in. long, are welded to open hearth doors at the central relining station set up in 1953 at the Gary Steel Works of U. S. Steel Corp. Placing of the doors on cleaning stands at an angle of about 75 degrees is an innovation at the central station. Figure 3 (right) — Venting with a five-pronged home-made tool is the last step before drying at the central station for relining open hearth furnace doors at the Gary Steel Works of U. S. Steel Corp.

Six Jacks Used to Elevate 300-Ton Beam Straightener

▲ ELEVATING a machine weighing 600,000 lb and covering 1200 sq ft of floor space with perfect accuracy was one of the challenges which confronted engineers at Blaw-Knox Co. when they designed a 300-ton beam straightener, reported to be the world's largest. The answer was six 50-ton worm gear jacks connected in series and powered by electric motors. At the touch of a push button, these jacks will raise or lower almost 300 tons a distance of 6½ in. to accommodate varying sizes of beams, stanchions and joists.

There are two sets of jacks on either side of the straightener, each set consisting of three jacks connected in series by shafting and 4-way mitre gear boxes. Each set of the jacks, which are manufactured by Duff-Norton Co. of Pittsburgh, is driven by a 7½ hp motor.

The beam straightener, now installed at U. S. Steel's Homestead (Pa.) Works, will straighten wide flange beams up to 24 in. in width and light beams, stanchions and joists down to six in. Five hundred horsepower drive the huge, 17-ft-high unit. It has nine rollers 36 in. in diam and vertical edgers in the front and rear. The straightener has four top rollers, which can be individually adjusted vertically, and five lower rollers. All are adjustable horizontally.

The Duff-Norton jacks used on the straightener have a worm gear ratio of 32:1. The screw lift is ¾ in. per min. Two jacks are located under each end of the straightener and two are under the middle. The distance between each end is 15 ft, 4 in. and each set of jacks is 7 ft, 10 in. apart.

It was necessary to make the pass line on the straightener adjustable because the approach tables in the Homestead Works' structural mill are fixed. When a change is made in the size of the beams being rolled, an operator raises or lowers the pass line to accommodate the difference. This can be done in a matter of seconds or minutes, depending on the amount of raise required.

The worm gear jack system was found to be very efficient in the beam straightener. It is so efficient, in fact, it has been possible to elevate the entire unit with only one 7½ hp motor instead of two. Moreover, no special engineering was required to design the jacks into the beam straightener. They are one of six standard models produced by Duff-Norton.

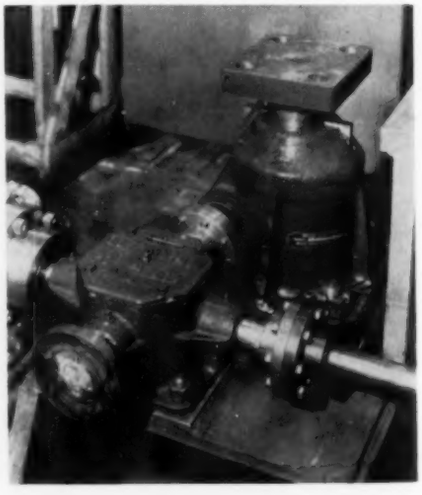
Although motors furnish the power to drive the worm gear jacks on the beam straightener and in most other applications, they also can be operated by hand cranks or hand wheels. Light loads may be lifted by using a handwheel. If a fine adjustment is required it can be obtained by using the largest gear ratio and largest number of turns for one-inch raise.

If a fast raise is needed, the lowest gear ratio and the least number of turns for one-in. raise should be used. The lowest gear ratio gives the highest jack efficiency. Consequently, it is the most suitable for motorized drives and since it requires the least turns for one inch of travel, it also is the most suitable for operation by hand.

The jacks can be used singly, in tandem or in multiple groups. When connected by shafting and mitre gear boxes, as on the straightener, the jacks raise or lower under equal or unequal loads in perfect unison. Once the worm gear jacks and gear boxes are connected, it is impossible for one jack to lag behind the others.

Figure 1—Six 50-ton worm gear jacks adjust the height of the pass line on this 300-ton beam straightener. They are driven by two 7½-hp motors and are push-button controlled.

Figure 2—The 4-way mitre gear box and shafting used to connect worm gear jacks in series are shown in this closeup of one of the 50-ton jacks installed on the 300-ton beam straightener.



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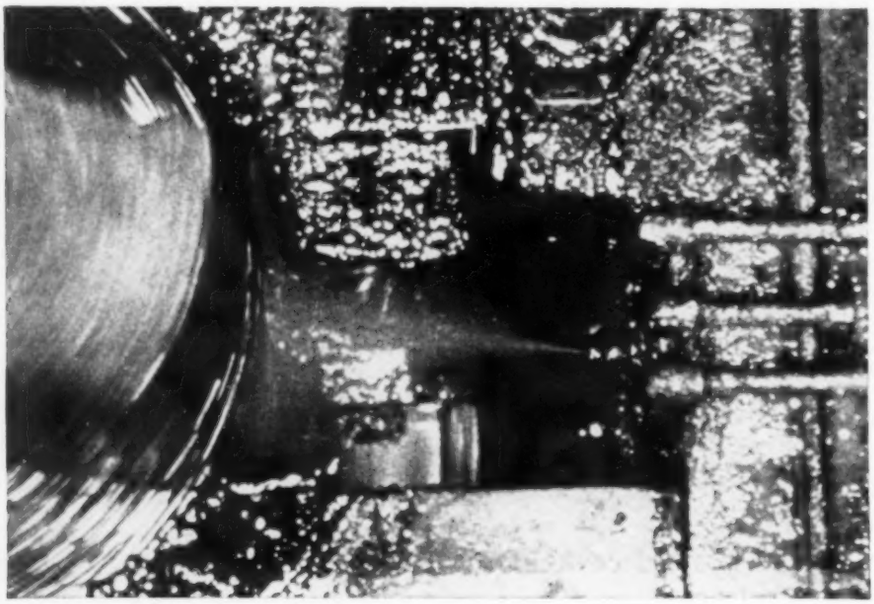
Lube Engineering News

A REPORT ON THE DIFFICULT LUBRICATING PROBLEMS OF INDUSTRY



SPRAY LUBRICATION OF ROLL NECK BEARINGS CUTS COSTS FIVE WAYS, STEEL MILL REPORTS

Lubrication of roll necks and bearings by means of a spray system employing a fluid lubricant, as shown in the unretouched photograph above, has proved far superior to the traditional system of forcing grease along grooves machined in the bearing surfaces, according to reports of an extended study recently completed by a major steel company.

Five major savings resulted from the use of the spray system:

1. The initial cost of preparing the bearings for service was reduced because it was not necessary to cut grease grooves. Also, the safe overall bearing area is substantially increased.
2. Lubricant consumption dropped from an average of 20 drums per week to approximately 3 drums.
3. Bearing life was substantially increased. With the old system of lubrication, bearings wore out in about 3 weeks. Bearings lubricated by the spray system showed no appreciable wear after 18 weeks of service.
4. Longer bearing and roll neck life also meant less time and cost for remachining and dressing.
5. Mill downtime was greatly reduced. With ordinary lubrication, 5 intervals of downtime would have been expected during the four months of the study period—with spray lubrication there was *no* downtime—saving thousands of dollars.

First adapted in 1949 and now being used by major steel companies for this important and severe application—the lubricant was Brook's Klingfast, a lead base fluid lubricant which retains its film strength (4 gram Timken test, 30 min. minimum—43 lbs. L.A.L.).

For complete data, write for Bulletin K-26.

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ELEVATED TEMPERATURE DRAWING Gives Steel Unique Properties

▲ A new process for the production of materials with a unique combination of physical and mechanical properties has been announced by La Salle Steel Co. of Hammond, Ind. This process has been named "e.t.d." (elevated temperature drawing). The properties depend upon: first, careful selection of a particular material composition of steel; second, the control of the amount of deformation by reduction; third, the temperature at which deformation is carried out to bring about metallurgical changes which result in a new combination of physical and mechanical properties not heretofore available. This procedure has been developed to create a new combination of properties. It is not designed to facilitate the deformation process.

This is an exclusive development of La Salle Steel Co. Four United States patents were granted October 23, 1956, covering this invention (Patent Nos. 2,767,835; 2,767,836; 2,767,837 and 2,767,838). Other United States and foreign patents and patent applications also describe this process.

For the first time in steel bar products, the dimensional tolerances, surface finish and excellent machinability generally associated with cold finished bars have been incorporated into a bar product which also has strength properties normally developed by heat treatment. (Heat treatment here is meant to describe the standard quench and temper cycle for hardening steel.) Further, it eliminates the need for heat treating and attendant operations in many instances for consumers.

Elevated temperature drawing involves the selection of bar chemistry, the amount of reduction in cross sectional area of the bar as it is drawn through a die and a drawing temperature which will result in the desired final properties.

These properties occur as a result of three metallurgical phenomena which take place in the bar as it is deformed at elevated temperatures (between 200 F and below the lower critical temperature).

First the steel bar strain hardens by appropriate slip processes within the crystal structure. Secondly, it age hardens by precipitation of nitrides along with precipitation of carbon from supersaturated solid solutions. Thirdly, a substructure within the grains develops as a result of the deformation at elevated temperatures.

Proper control of these metallurgical processes results in the unique combination of properties which are produced.

Figure 1—Long parts such as those shown: milling machine spindle, power take off shaft, main drive shaft on heavy duty lathe are produced economically because they require no subsequent heat treating. Therefore the distortion that goes into quenching is absent.

On September 6, 1955 "fatigue-proof," a new material embodying a new combination of properties made by the new process, was first made available commercially.

The product made from a carbon steel was designed and meets specifications set up to answer, at least to some degree, three basic materials problems.

For the first time a steel bar product is offered commercially which has guaranteed Rockwell C values of 30, a tensile strength of 140,000 psi and a yield strength of 125,000 psi. In addition, the material has remarkable free machining characteristics. It machines about 25 per cent faster than annealed alloy steel and as much as 100 per cent faster than alloy steel heat treated to the same strength level.

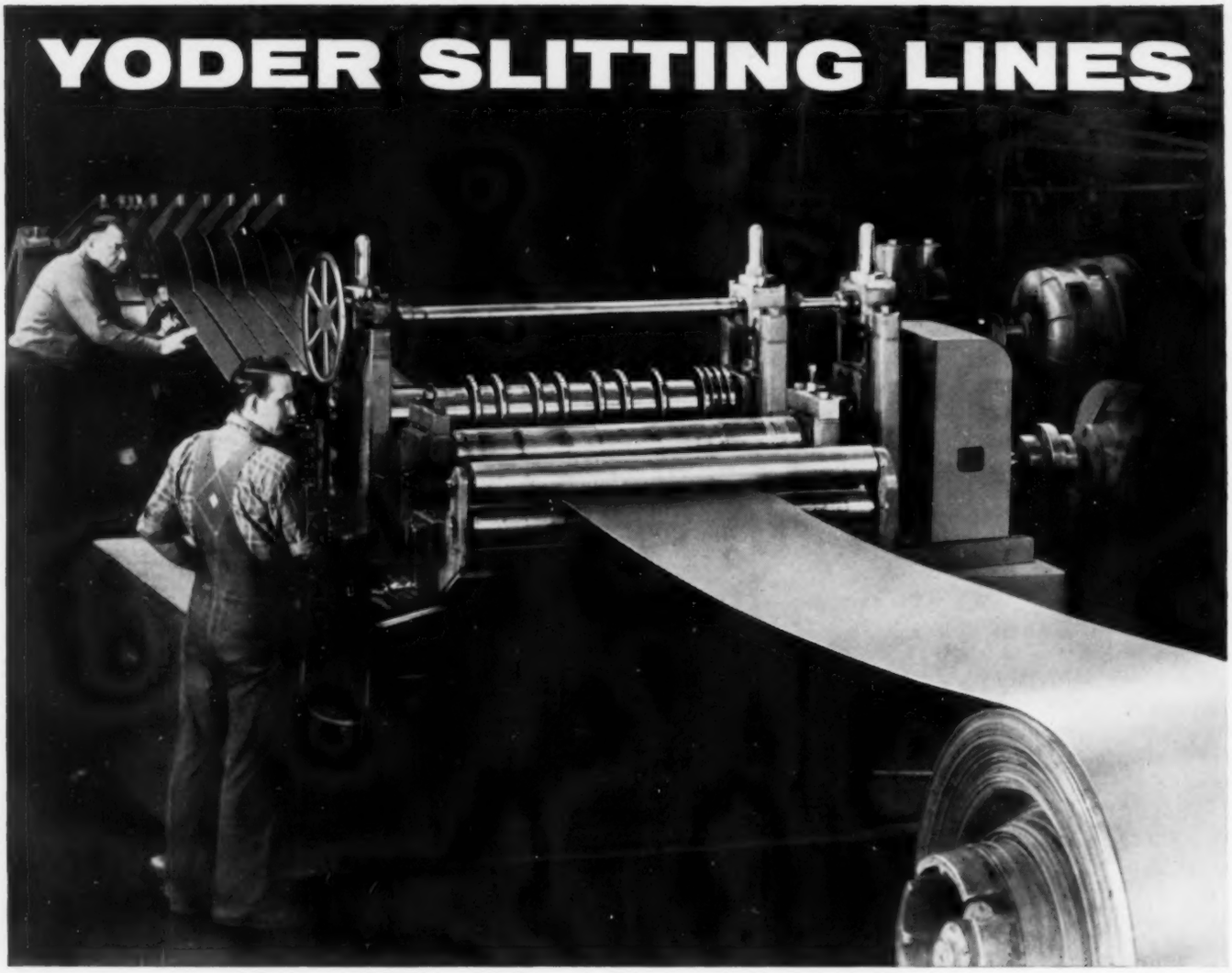
Inherent in the manufacturing procedure is a uniformity of property from heat to heat, bar to bar and across the diameter of the bar which has heretofore not been available in quenched and tempered bar stock.

To summarize:

The "e.t.d." process holds promise of bringing about the following:

1. The lessening of the dependence on strategically scarce alloys.
2. The making possible of combinations of properties not economically attainable by present methods.
3. In many cases the elimination of heat treatment and subsequent operations.
4. The combination of high strength with improved machinability.
5. The direct production by machining operations only of parts which have before required multiple and often costly operations.

YODER SLITTING LINES



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In one plant, two Yoder tube mills and about 50 punch presses are being supplied with slit strands by one Yoder Slitting Line operated an average of only *seven hours per week.*

In another plant, a Yoder slitting line, *operated from six to eight hours per week,* is supplying two intermittently operated roll forming machines with total requirements averaging 100,000 feet per week.

These typical examples demonstrate, first, the big potential output of a relatively small, inexpensive Yoder standardized Slitting Line and, secondly, its big profitability. Assume production of only 35 tons of slit strands per 8 hour shift, one day per week, and the total per year would be 1750 tons. Estimating the saving in slitting cost at only one-half cent per lb., the total annual saving would be $17,500.00.

Besides the big convenience of doing your own slitting, such savings will often repay the investment in a few months.

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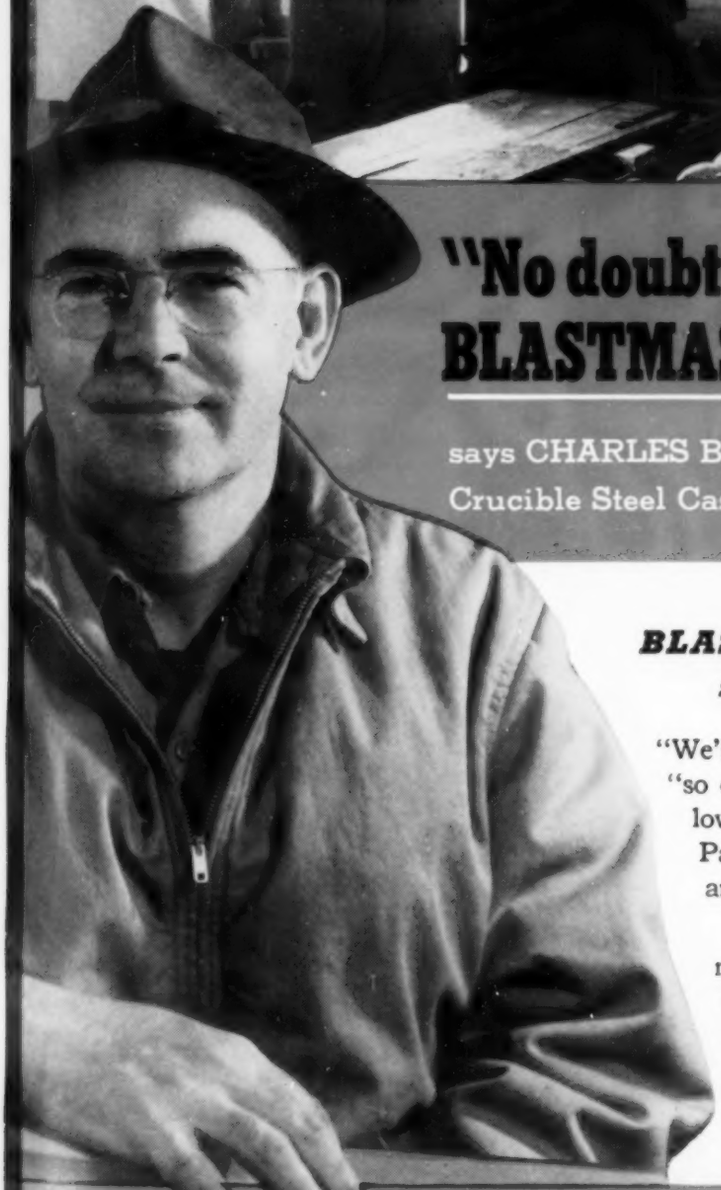

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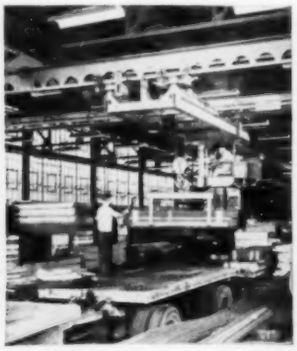
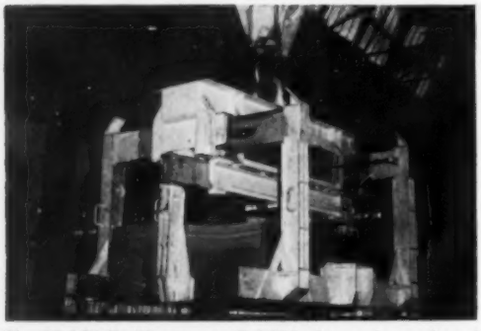
You don't perform all of your manufacturing operations on a lathe. Then why try to handle all your sheets of various widths with one grab? If the minimum width of sheet handled in your plant is less than 4/10 of the maximum width, you can make important savings by using a separate Mansaver Sheet Grab for each range.

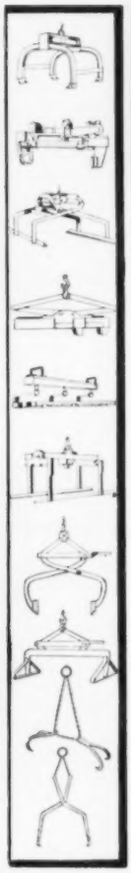


The Style G-1142 Mansaver shown at the left above is loading a car of cold rolled steel. The G-1142 cab-controlled Mansaver at the right is unloading 5-ton bundles of sheet steel from a motor truck. This load was handled in 11 minutes!

The 14′ Mansaver Sheet Grab above has a lift of two packages 36 x 120 cold rolled sheets weighing 14,280 lbs. at the shear line.



The 30,000-lb. Mansaver, G-1456 above, is equipped with end hooks and is handling sheets varying from 24″ to 72″ wide, and from 72″ to 168″ long.

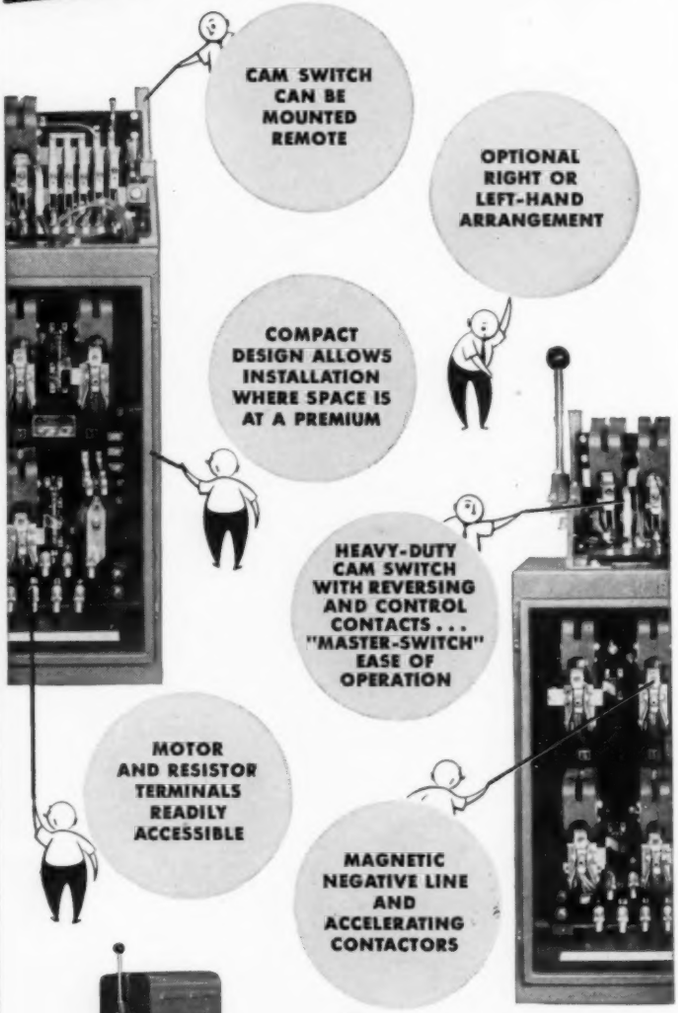


Mansaver Sheet Grabs are used in more than 700 plants. They are there because of their ease of operation, and the low head room, and minimum aisle space they require. They are designed with ample safety factors, and to give uninterrupted service with low maintenance. Write for circulars and nearest representative.

MANSAVER INDUSTRIES, INC., 3116 East St., New Haven, Conn.

NEW
HEAVY-DUTY D-C MAN-NETIC CONTROLLERS*

COMBINATION MANUAL and MAGNETIC CONTROLLER FOR CRANES—CHARGING MACHINES—D-C CONTROL JOBS


CAM SWITCH CAN BE MOUNTED REMOTE
OPTIONAL RIGHT OR LEFT-HAND ARRANGEMENT
COMPACT DESIGN ALLOWS INSTALLATION WHERE SPACE IS AT A PREMIUM
HEAVY-DUTY CAM SWITCH WITH REVERSING AND CONTROL CONTACTS . . . "MASTER-SWITCH" EASE OF OPERATION
MOTOR AND RESISTOR TERMINALS READILY ACCESSIBLE
MAGNETIC NEGATIVE LINE AND ACCELERATING CONTACTORS
TOE SPACE FOR OPERATOR'S COMFORT

2 TYPES AVAILABLE: REVERSE-PLUGGING OR DYNAMIC - LOWERING

Provide four speed points, reversing, with all advantages of full-magnetic control. Manually-operated cam contacts are free of destructive arcing . . . extremely fast magnetic contactor action interrupts power circuit before cam-operated contacts are opened. EUCLID'S EXCLUSIVE "TIMELOK" feature offers maximum dependable acceleration timing without extra relays . . . permits unusually compact arrangement of the magnetic panel.

For more information, contact our representative in your area, or write or call THE EUCLID ELECTRIC & MFG. CO., MADISON, OHIO.
Ask for Bulletin 4400-4401.

*PATENT APPLIED FOR.

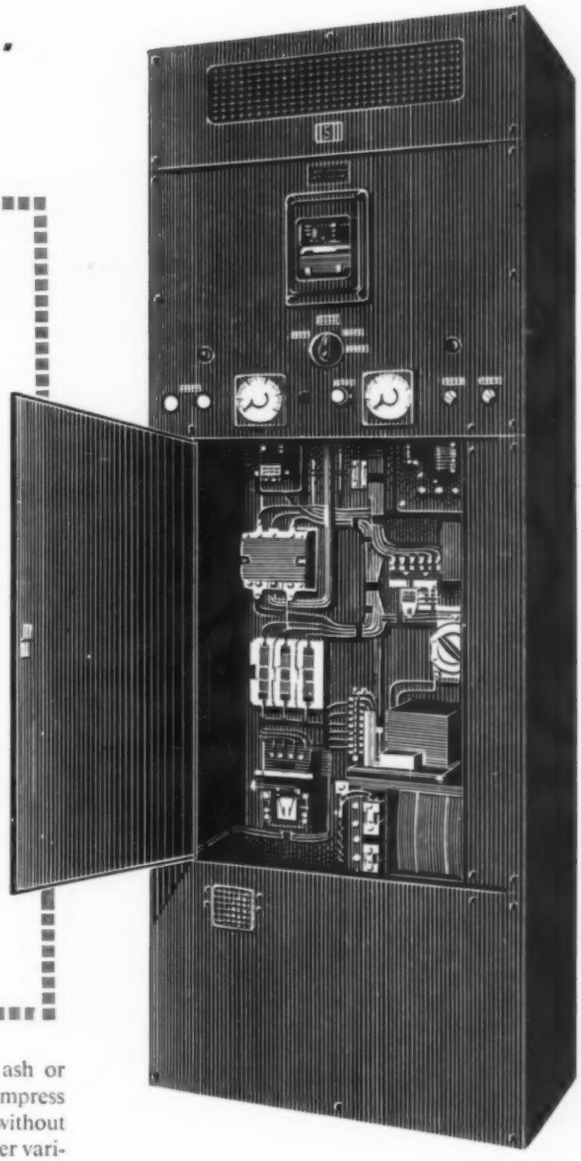
THE EUCLID ELECTRIC & MFG. CO.
MADISON, OHIO

THE EUCLID ELECTRIC
EUCLID
AND MFG. CO., MADISON, OHIO

New Automatic Precipitator Control by

WESTERN PRECIPITATION

offers many vital advantages...



1 LONG LIFE

This new control has indefinite life expectancy under all types of operating conditions. There are no tubes to replace, no high speed relays, counters, or timers to maintain. All circuitry consists of rugged "static" devices that have unusually long life!

2 RELIABILITY

Optimum Precipitator power input is maintained regardless of operating conditions. The sensing control is simple, positive, accurate—and automatically evaluates the spark "Power Value" (intensity and frequency)—not just frequency or intensity alone.

3 STABILITY

Under short circuit, open circuit or other varying conditions, this control is completely stable and inherently trouble-free!

4 MODEST COST

Modest initial cost coupled with negligible maintenance assure optimum operating efficiency (therefore lower operating costs) throughout many years of continuous service.

WHEN using a Cottrell Precipitator for collecting dust, fume, fly ash or other suspensions from industrial gases, it is essential at all times to impress on the high voltage system the highest possible voltage and current without "flashover". Depending upon gas conditions, dust loading and other variable factors, the optimum voltage and current requirements vary widely from one minute to the next. Therefore, the vital importance of a simple, trouble-free and highly sensitive Precipitator Control is self-evident.

This new Western Precipitation Automatic Precipitator Control—*a product of the organization that has consistently led in the application of Cottrell Precipitators for industrial gas cleaning* — combines vital advantages found in no other competitive equipment. Our nearest representative will be glad to supply complete details. Or write direct!

Why not modernize your present out-dated Precipitator installation? The Western Precipitation Automatic Precipitator Control can be installed on any Cottrell unit. For further information contact our nearest office!

Western Precipitation Corporation

Designers and Manufacturers of Equipment for Collection of Suspended Material from Gases
..and Equipment for the Process Industries

Main Offices: **1067 WEST NINTH STREET, LOS ANGELES 54, CALIFORNIA**

Chrysler Building, New York 17 • 1 North La Salle Street Building, Chicago 2 • Oliver Building, Pittsburgh 22 • 3252 Peachtree Road N. E., Atlanta 5 • Hobart Building, San Francisco 4

Precipitation Company of Canada Ltd., Dominion Square Building, Montreal

Representatives in all principal cities

COTTRELL Electrical Precipitators
MULTICLONE Mechanical Collectors
CMP Combination Units
DUALAIRE Reverse-Jet Filters
HOLO-FLITE Processors

here's how Dowell chemical cleaning saved $71,000 and helped protect a plant profit!

A few months before their peak season, the operators of this plant decided their main water line might not supply the water necessary to meet peak demands. The line was cast-iron, 16-inches in diameter and over 7,000 feet long. Its original flow efficiency or "C" factor had been 105; scale build-up had reduced this to 72. To lay an auxiliary line would cost at least $85,000.

Dowell contracted to clean the pipe chemically for a little less than $14,000, and to restore a minimum of 50 per cent of the line's lost capacity.

This Dowell did, and more—increasing the "C" factor to 92! Enough water was immediately available for capacity operation. This saved the plant $71,000 and helped protect the company's annual profit.

The operating credit realized by this food processing plant, as a result of Dowell service, is similar to those realized by other Dowell customers—in the steel, paper, chemical, oil refining, power and allied industries.

Dowell engineers are experts in the use of solvents to remove scale and sludge—deposits that cut the throughput of product, process and steam generating systems. Dowell does the job, furnishing all chemicals, trained personnel, pumping and control equipment.

For specific information on how chemical cleaning can help you to greater profits, call the Dowell office nearest you. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

Have Dowell clean it chemically DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Date-line Diary...

January 2

▲ ICC authorized western railroads and eight eastern lines a 5 per cent raise in first class and coach passenger fares and approved a 7 per cent increase in Pullman and parlor car charges.

▲ The consensus of regional boards representing 26,000 shippers is that railroad freight traffic nationwise in the first quarter of 1957 will rise 3.7 per cent above the same period of 1956. Carloadings for 1956 were about one per cent above 1955.

▲ Shipments of iron and steel castings during October 1956 amounted to 1,531,892 short tons compared with 1,334,369 short tons in September, 1956, and 1,546,849 short tons in October, 1955. Shipments in November, 1956, totaled 1,422,403 short tons, November, 1955, 1,557,294 short tons.

January 3

▲ Auto production in Dec., 1956, totaled 596,238, up 10.3 per cent over November, 1956, but 12.6 per cent below December, 1955. Output for 1956 declined to 5,801,295 cars, 27 per cent below the 1955 total.

▲ The ICC was requested to approve a 5 per cent increase in coach and first class passenger fares by 17 eastern railroads to match the increase granted 8 other eastern roads.

▲ Consumer debt in November increased $213,000,000 to a total installment debt of $31,000,000,000 more than $2,800,000,000 higher than November, 1955.

▲ The National Coal Association advises that soft coal production in the U. S. amounted to 500,000,000 tons in 1956, 6.4 per cent greater than 1955.

January 4

▲ Bethlehem Steel Corp. and Youngstown Sheet & Tube Co. requested the Court to dismiss the anti-trust suit against their merger contending that there is no substantial competition between the two companies in any section of the country and further that the proposed merger will stimulate competition in the steel industry in various sections of the country. They denied the government charges that a merger would reduce competition and was a violation of the Clayton act.

January 7

▲ Republic Steel Corp. announced it will further expand the Gadsden plant by the addition of a second electric furnace.

▲ The AISI reports that the operating rate of the steel industry for the week of January 7 is scheduled at 98.3 per cent of capacity. This is equivalent to 2,517,000 tons compared with 2,490,000 tons one week ago and 2,428,000 tons one year ago. Index of production for the week is 156.7.

January 8

▲ Prices of steel scrap declined $4 a ton in Pittsburgh, and No. 1 heavy melting scrap sold at $63 a ton.

▲ Cartier Mining Co. Ltd., subsidiary of U. S. Steel Corp., plans to form a new Quebec company to investigate and develop a large iron ore mining site north of Shelter Bay, Quebec.

▲ AISC reports that shipments of fabricated structural steel for November amounted to 276,045 tons compared with 287,639 tons in October, 1956, and 258,883 tons in November, 1955, bookings totaled 338,892 tons compared with 290,961 in October and 341,308 in November, 1955. Backlog on Nov. 30 was 3,252,202 tons.

January 11

▲ A group of 40 home builders meeting with government housing and monetary officials predicted that housing starts will number about 900,000 in 1957 compared with 1,100,000 in 1956.

▲ AISI reports the estimated total November payroll for the iron and steel industry amounted to $346,041,000; estimated total employment, 688,900; average hourly payroll cost for wage earners, $2.792 (plus an average cost of about 25¢ an hour for pensions, social security and insurance, estimated on an annual basis). Average hours worked were 39.8.

January 14

▲ The AISI reports that the operating rate of the steel industry for the week of January 14 is scheduled at 98.3 per cent of capacity. This is equivalent to 2,517,000 tons compared with 2,519,000 tons one week ago and 2,437,000 tons one year ago. Index of production for the week is 156.7.

▲ The Bureau of Mines reports that the consumption of scrap during November, 1956, totaled 6,315,000 gross tons and pig iron 6,235,000 gross tons compared with 6,722,320 tons of scrap and 6,450,404 tons of pig iron in October.

▲ Prices on steel products were increased by two companies, Kaiser Steel Corp., Oakland, announced increases of 50¢ to $2 a ton on nearly all its products; Allegheny Ludlum, Pittsburgh, raised base prices for special high-nickel electrical alloys.

▲ J & L Steel Corp. announced it will close one of its mines at California, Pa., April 1, 1956, because it is largely depleted. Approximately 790 employees will be laid off.

January 15

▲ F. W. Dodge Corp. reports that home building contracts in 1956 in the 37 states east of the Rockies amounted to $9,826,460,000, 4 per cent below 1955; contracts let for all types of construction rose to $24,412,630,000, an increase of 3 per cent over 1955. Residential awards for December, 1956, were $450,646,000 or 37 per cent under December, 1955.

▲ The 2-for-1 split of common stock was approved today by the stockholders of Crucible Steel Co. of America, effective at the close of business January 18, 1957. There will be 5,000,000 shares at $12.50 par value each authorized and 3,636,457 shares outstanding when the split becomes effective.

January 16

▲ Iron and steel companies plan to spend $1,700,000,000 for new equipment and construction in 1957 reports the AISI. In the years 1946 to 1956 inclusive, the industry spent $8,000,000,000 for like expansion, outlay in 1956 amounted to $1,200,000,000.

▲ Harmon S. Eberhard, president of Caterpillar Tractor Company, in an address at a conference of American Bankers Association, forecast that highway expenditures will exceed $10,000,000,000 yearly when the new road building program hits its peak.
▲ U. S. Steel Corp., Homestead works, will idle its No. 4 blast furnace 26 days for repairs, leaving five blast furnaces in operation.

January 17

▲ President Eisenhower estimated government revenues for the fiscal year 1957–58 at $73,600,000,000, resulting in approximately $1,800,000,000 surplus. For the current year he forecasts a $1,700,000,000 surplus. However, tax cuts must wait at least another year, he said, in urging Congress to continue current corporate and excise tax rates.
▲ U. S. Steel Corp. boosted prices 3½ per cent on steel pipe in sizes over 14 in., effective today, as well as increases in extra charges amounting to 4½ per cent for carbon structural shapes and 5½ per cent for carbon plates. These mark-ups in extra charges were similar to advances recently made by Bethlehem and Inland.
▲ The Aluminum Assn. reports primary aluminum production in the United States during December, 1956, was 297,149,096 lb compared with 290,162,159 lb in November, 1956, and 281,364,018 lb in December, 1955.

January 18

▲ ARCI reports that deliveries of new domestic freight cars in December totaled 7,260 cars compared with 6,695 cars in November and 3,796 in December, 1955. Orders in December totaled 4,992 compared with 4,172 in November. Backlog of cars on order as of January 1, 1957, stood at 117,257 cars.
▲ Stockholders of Bethlehem Steel Corp. approved a four-to-one split of its common stock which will result in a total of 40,090,228, of $8 par value shares of common stock outstanding.
▲ $19,903,300 in Series A, 4¾ per cent convertible sinking fund debentures were registered with SEC by Colorado Fuel & Iron, for subscription by common stockholders in the ratio of $100 for each 17 shares held. Purpose is to reduce the $12,000,000 outstanding under a loan agreement with banks, to retire $6,000,000 of other bank loans, and to provide more working capital.

January 19

▲ Shipments of finished steel products totaled 7,431,136 net tons for November, 1956, compared with 7,930,957 tons for October, 1956, and 7,247,994 tons in November, 1955, according to statistics released by the AISI.

January 21

▲ Resistance Welder Manufacturers Assn. reports shipments by members for December amounted to $3,820,000, backlog on January 1, 1957, was slightly in excess of $12,000,000.
▲ The AISI reports that the operating rate of the steel industry for the week of January 21, is scheduled at 97.5 per cent of capacity. This is equivalent to 2,496,000 tons compared with 2,467,000 tons one week ago and 2,472,000 tons one year ago. Index of production for the week is 155.4.

January 22

▲ According to the AISI, blast furnace production in the U. S. in 1956 totaled 75,965,475 net tons of pig iron and ferro-alloys, compared with 77,789,674 net tons in 1955; output during December reached 7,334,584 net tons. Output of alloy steel during 1956 was 10,380,941 net tons, in 1955 10,660,091 net tons; the revised total for 1956 steel production is 115,216,149 net tons of ingots and steel for castings.

January 24

▲ Custom smelters reduced price for refined copper to 34¾¢ per lb, down ¼¢. Industry figures showed that copper use by brass and wire mills and foundries in December, 1956, were 99,223 tons, down 20,000 tons from November, 1956.
▲ F. F. Estes, executive secretary of the Coal Exporters Assn. reported that bituminous coal exports from the U. S. topped 48,000,000 tons in 1956 and may run even higher than 56,000,000 tons in 1957.

January 28

▲ The AISI reports that the operating rate of the steel industry for the week of January 28, is scheduled at 97.1 per cent of capacity. This is equivalent to 2,485,000 tons compared with 2,472,000 tons one week ago and 2,444,000 tons one year ago. Index of production for the week is 154.7.
▲ American Zinc Institute, Inc., reported that domestic smelter production of slab zinc for 1956 reached an all time high of 1,062,954 tons.
▲ A 6-day wildcat strike, affecting 1800 employees, ended at Wheeling Steel when the union agreed to process the dispute over suspension of 6 employees the company claimed were involved in a work slowdown, through the grievance procedures established by the current contract.
▲ George E. Leighty, head of bargaining group for 11 non-operating unions representing 728,000 rail employees, disclosed that major railroads will soon be confronted with union demands for broad layoff pay plan or some other form of increased unemployment compensation.

January 29

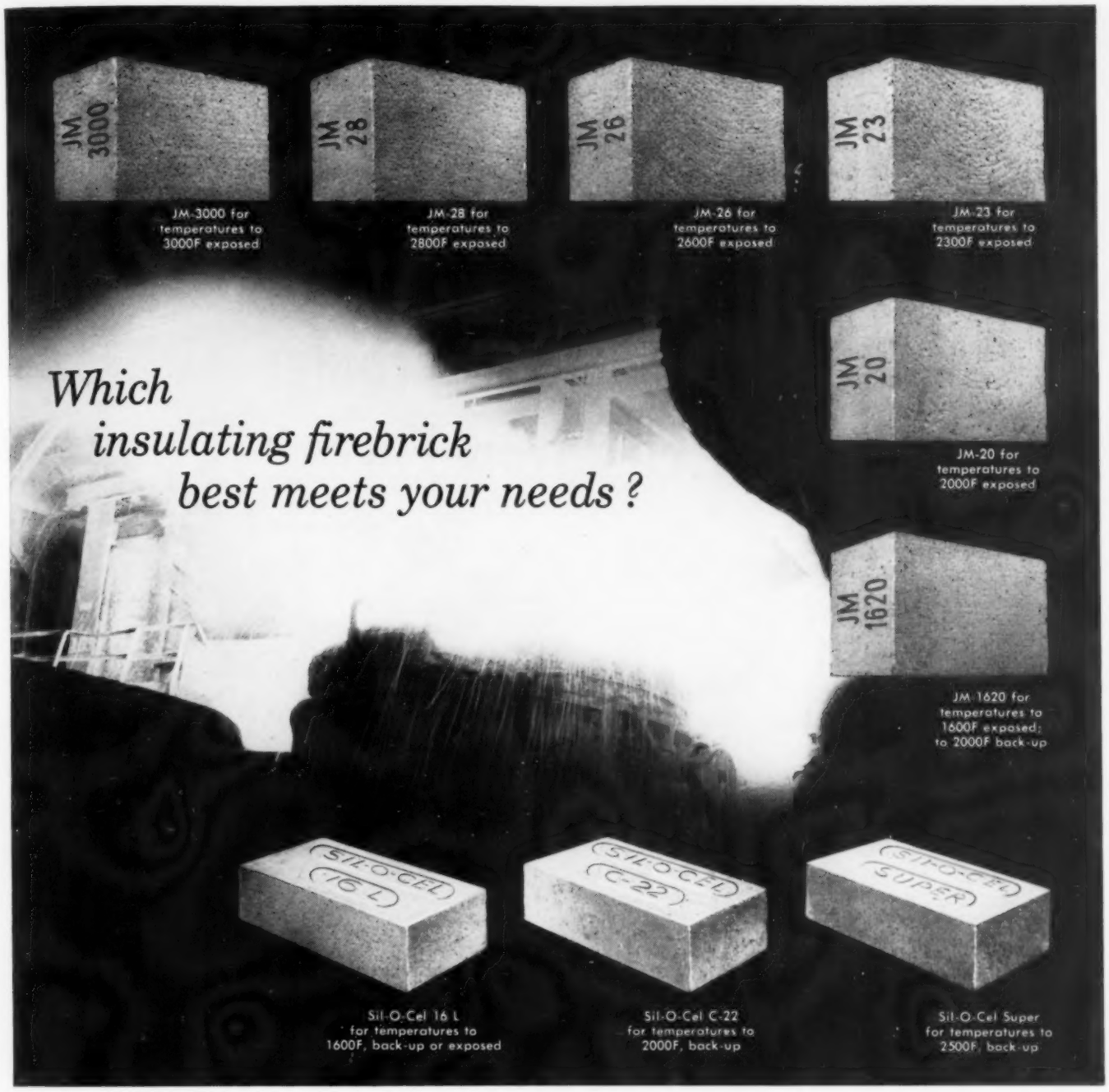
▲ Steel scrap prices in Pittsburgh declined to $55 a ton for No. 1 heavy melting, down $8 a ton.

January 30

▲ Prices of scrap copper declined to 26½¢ a lb for No. 2 copper wire, down as much as ½¢.

January 31

▲ World raw steel production in 1956 totaled 311,000,000 net tons according to AISI estimate on the basis of various figures published in business magazines, up 17,000,000 tons over 1955. U. S. output led with 115,000,000 tons, Russia 54,000,000, West Germany 26,000,000, Great Britain 23,000,000, France 15,000,000 and Japan 12,000,000—production by the free world amounted to 235,000,000 tons exceeding 1955 by 10,000,000 tons, seven Communist dominated countries produced 76,000,000 tons about 7,000,000 tons over 1955.
▲ Phelps Dodge Corp. cut copper price to 34¢ a lb, 2¢ decline.
▲ Cleveland-Cliffs Iron Co. boosted iron ore prices 60¢ a gross ton, more than 5 per cent, for shipments of Lake Superior ores during 1957.
▲ Company officials in New York disclosed the consolidation, through an exchange of stock, of August Thyssen-Huette, A. G. of Duisburg-Hamborn, and Niederrheinische Huette, A. G., West Germany.


JM 3000
JM-3000 for temperatures to 3000F exposed
JM 28
JM-28 for temperatures to 2800F exposed
JM 26
JM-26 for temperatures to 2600F exposed
JM 23
JM-23 for temperatures to 2300F exposed
Which insulating firebrick best meets your needs?
JM 20
JM-20 for temperatures to 2000F exposed
JM 1620
JM-1620 for temperatures to 1600F exposed; to 2000F back-up
SIL-O-CEL 16 L
SIL-O-CEL C-22
SIL-O-CEL SUPER
Sil-O-Cel 16 L for temperatures to 1600F, back-up or exposed
Sil-O-Cel C-22 for temperatures to 2000F, back-up
Sil-O-Cel Super for temperatures to 2500F, back-up

Only Johns-Manville's insulating brick family offers the right combination of properties . . . *for furnace requirements to 3000F!*

J-M's nine *different* insulating firebrick* means you never have to settle for a brick that's nearly right! Instead, you choose the one brick that best meets your needs . . . for such important properties as temperature resistance, load-bearing strength, conductivity and density.

Johns-Manville has two strategically located plants for the production of insulating brick: Lompoc, California, and Zelienople, Pennsylvania. Brick are available from the stocks of authorized Johns-Manville distributors in key industrial areas.

For complete information, call your nearest J-M representative. Or write for brochure IN-115A to Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

**Sil-O-Cel® Super and C-22 insulating brick are for back-up use only*

JM PRODUCTS **Johns-Manville** REFRACTORY AND INSULATING REFRACTORY PRODUCTS

"Heating in our switch was causing 'lights-out' shutdowns until we changed to cooler operating Fusetron Fuses"

Thomas Lavin, Building Engineer
Railway Exchange Building
Denver, Colorado

Mr. Lavin Continues:

"We had considerable trouble with heat developing in a lighting switch and causing fuse blows. It was very annoying having the lights go out so often—and having regular maintenance work interrupted to replace fuses.

"Checking with an ammeter we found the continued load to be 28 ampere. This indicated that 30 ampere fuses in use were the right size for safe protection. Nevertheless, the renewable fuses we had installed kept blowing.

"Evidently, what we needed were the same size fuses that would operate cooler to eliminate heating in the switch.

"At the suggestion of a salesman we tried 30 ampere Fusetron dual-element fuses. Our heating problem immediately disappeared. This was 7 or 8 months ago and we have had no trouble with the switch overheating—and our—'lights-out' shutdowns are a thing of the past."

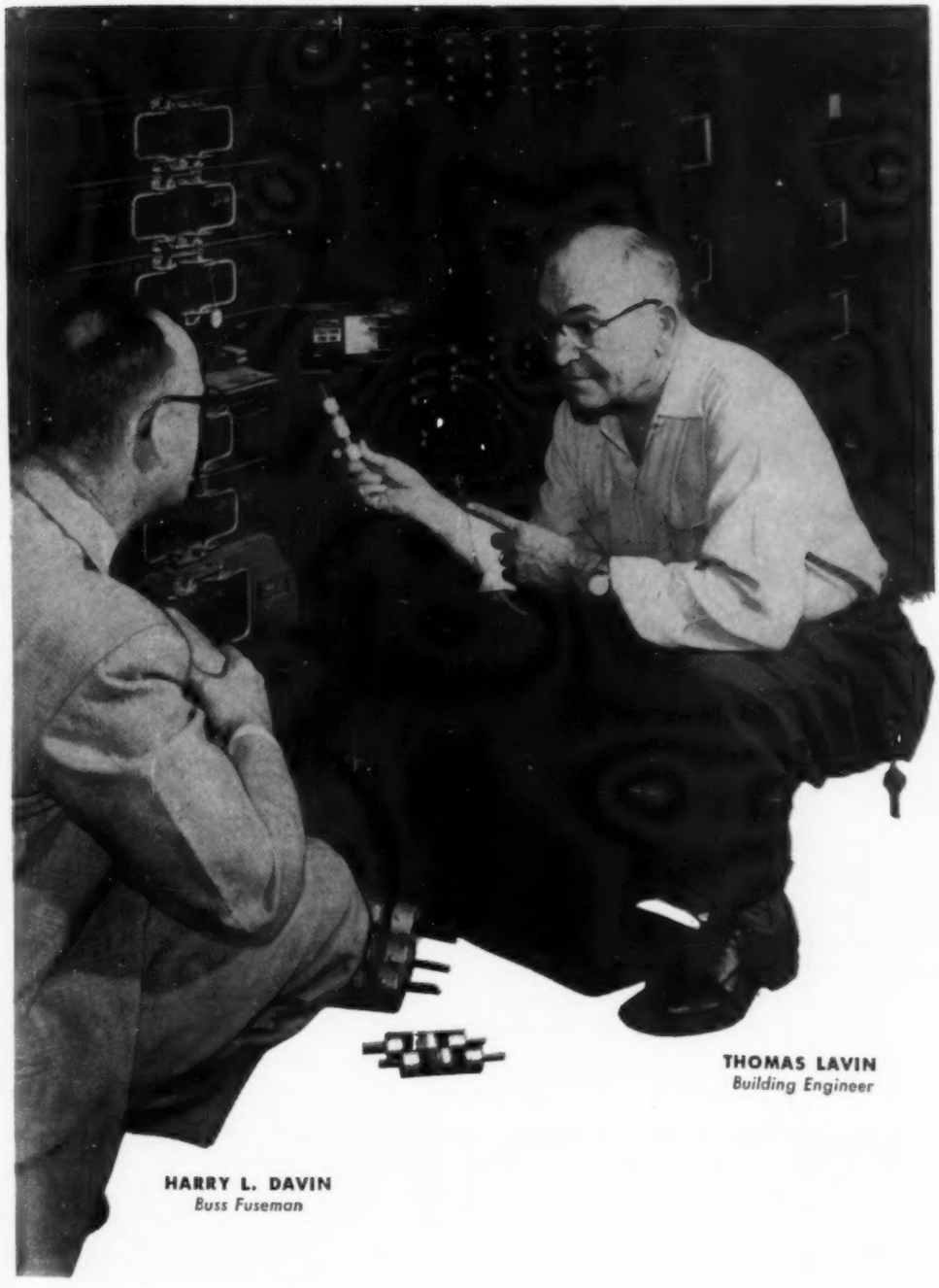
Here's why Fusetron Fuses protect against needless blows caused by excessive heating of panels and switches

Fuses, like other protective devices operate from heat created by the current flowing through them. Thus they produce some heat even in normal operation.

Sometimes the heat is not dissipated from switches and panels fast enough. This piled up heat over-heats fuses and reduces their carrying capacity. Then fuses often blow even though not loaded to their rated capacity.

A logical answer to this heating problem is the use of Fusetron fuses. Fusetron fuses produce less heat because they have less electrical resistance than ordinary fuses. For example, ordinary fuses have 55 to 117% greater resistance than Fusetron fuses in 250 volt sizes and up to 140% greater resistance for 600 volt sizes.

Since the lower resistance of Fusetron dual-element fuses means less generation of heat, switches and panels operate much cooler. This materially reduces or wipes out entirely useless shutdowns caused by fuses blowing due to overheating of panels and switches.



THOMAS LAVIN
Building Engineer

HARRY L. DAVIN
Buss Fuseman

Save time, trouble and money by using Fusetron dual-element Fuses.

THEY PROVIDE 10 POINT PROTECTION

1 High interrupting capacity—protect against heaviest short circuits. Have proven on tests to open safely on circuits set to deliver in excess of 100,000 amperes. **2** Protect against needless blows caused by excessive heating—lesser resistance results in cooler operation. **3** Protect against needless blows caused by harmless overloads. **4** Provide thermal protection—for panels and switches against damage from heating due to poor contact. **5** Protect against waste of space and money—permit use of proper size switches and panels. **6** Protect motors against burnout from overloads. **7** Give DOUBLE burnout protection to large motors—without extra cost. **8** Protect motors against burnout due to single phasing. **9** Make protection of small motors simple and inexpensive. **10** Protect coils, transformers and solenoids against burnout.

Write for bulletin FIS.

FOR LOADS ABOVE 600 AND UP TO 5000 AMPS. — USE BUSS Hi-Cap FUSES!

They have an interrupting capacity sufficient to handle any fault current regardless of system growth.

They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuit of origin.

Write for bulletin HCS.

Play Safe! *install FUSETRON dual-element Fuses and BUSS Hi-Cap Fuses throughout entire Electrical System!*

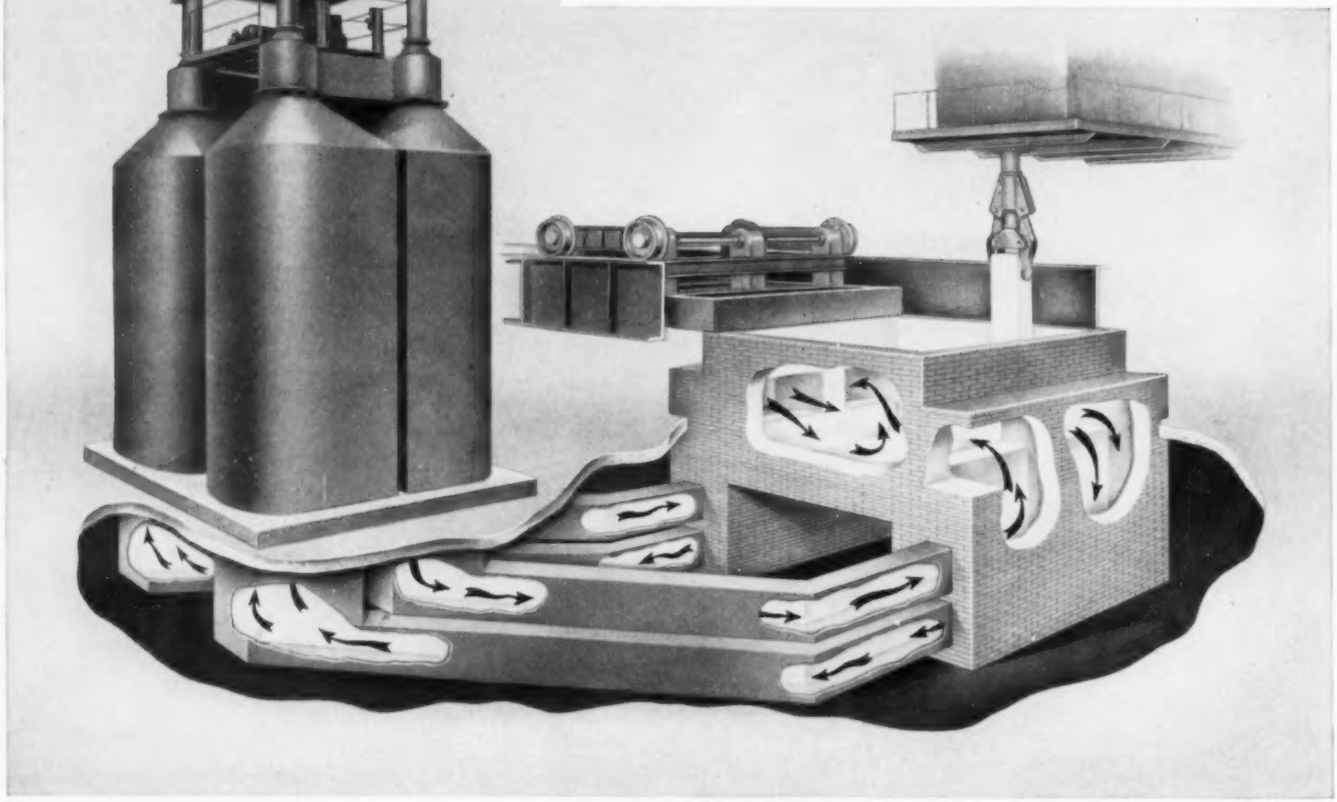
BUSSMANN MFG. CO.
(Div. of McGraw Electric Co.)
University at Jefferson,
St. Louis 7, Mo

FUSETRON
BUSS

157

HEAT MORE STEEL with MORGAN-ISLEY

The Morgan-Isley system offers you a better means of heating ingots with straight blast furnace gas, coke oven gas, natural gas or oil.



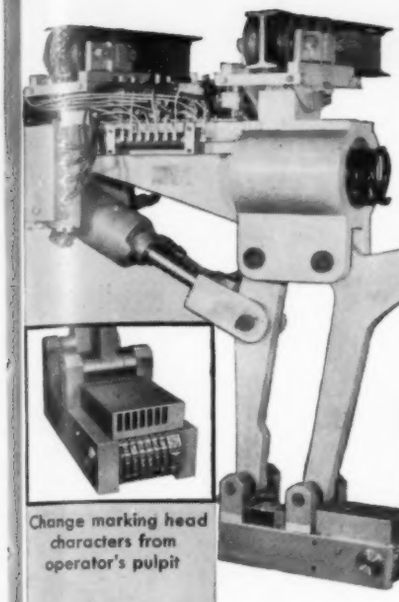
The schematic shows the flow of combustion air and flue gases through the regenerators and soaking pit. The Morgan-Isley system employs vertical regenerators. It eliminates regenerator capacity under the crane runway thus freeing this valuable area for heating steel.

CCC-49

MORGAN CONSTRUCTION COMPANY WORCESTER, MASS.

ROLLING MILLS • MORGOIL BEARINGS • REGENERATIVE FURNACE CONTROLS • EJECTORS • PRODUCER GAS MACHINES

H.H. Wood, Representative, Koppers Building, Pittsburgh, Pennsylvania



How to mark
BLOOMS, SLABS and BILLETS
by
REMOTE CONTROL

Change marking head characters from operator's pulpit

Mecco SAFETY BILLET MARKER

New marking head allows cut letters and ingot numbers to be changed instantly from the operator's pulpit. Wide versatility for stamping ends of blooms, slabs, and billets. *Write for Bulletin 613-D on new Billet Marker.*

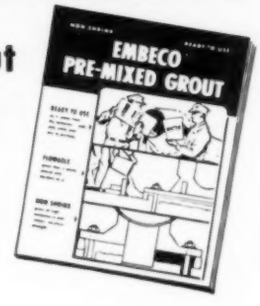
A product of the Marking Device Industry

M. E. CUNNINGHAM CO.

1041 CHATEAU STREET, PITTSBURGH 33, PA.

READ THIS GROUTING GUIDE

... before you Grout another piece of heavy equipment

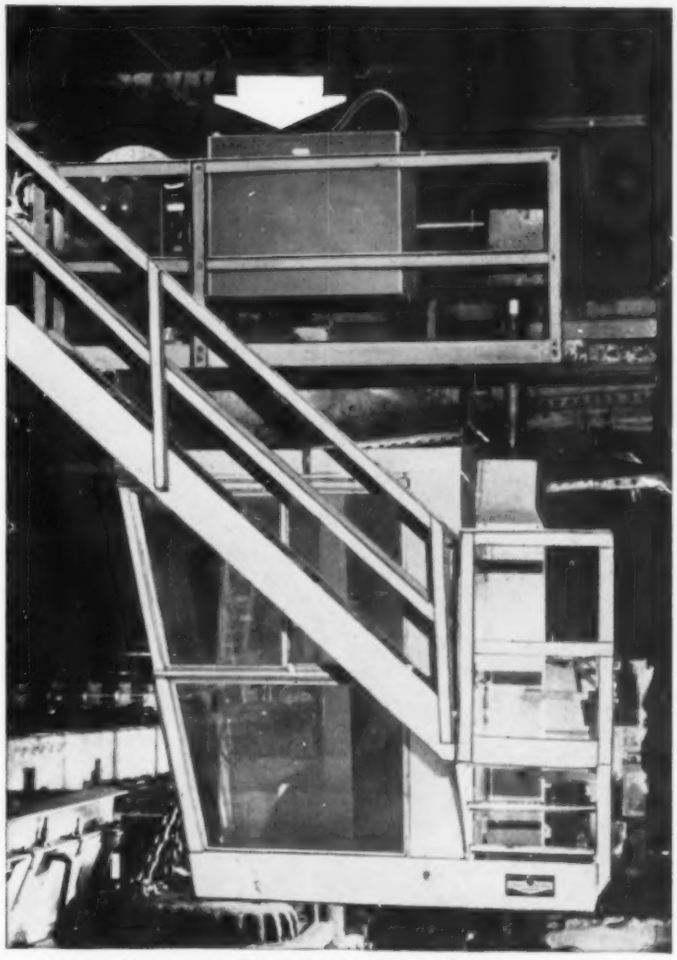


Send for this *free* grouting guide which clearly illustrates 11 common machinery settings, methods of grouting and forming, and hot and cold weather grouting. Discussion covers proper mixing and placing of grout, reasons for using prepared, non-shrink grout, etc.

DIVISION OF AMERICAN-MARIETTA COMPANY

the MASTER BUILDERS CO.

CLEVELAND 3, OHIO TORONTO 9, ONTARIO



Lintern Aire-Rectifier (Model 513 AC-3S). Condenser, mounted on crane, is connected with cooling unit in cab by refrigerant lines of high pressure hydraulic hose.

What Happened at THE TIMKEN COMPANY Since Installation of AIRE-RECTIFIERS

Several years ago The Timken Roller Bearing Co., of Canton, Ohio, installed its first Aire-Rectifier to air condition one of the crane cabs in its steel mill. The company now has several cranes, Lintern-equipped.

In the air conditioned cab, an operator works an uninterrupted 8-hour trick in complete comfort — even over soaking pits.

Air conditioning of crane cabs, according to The Timken Roller Bearing Co., has resulted in more efficient utilization of manpower, greatly improved working conditions, and safer crane operation.

Such is the experience of hundreds of companies using Lintern Aire-Rectifiers. May we discuss your situation with you? Ask for Bulletin AC 561.

Larco, inc.
DISTRIBUTORS OF LINTERN CORPORATION PRODUCTS
ROUTE 20, EAST • PAINESVILLE, OHIO

engineering teamwork plus

NBD DESIGN ANALYSIS

adds cooling efficiency and economy

to blast furnace operation

The ideas came from customers.

Practical application of the ideas into a design was NBD's job.

Teamwork between NBD and customer engineering made it possible.

The result: a cleanly designed, vertical baffle bosh plate that eliminates the possibility of entrapped air and allows faster water circulation for more even, more efficient cooling. Its rectangular design adds economy, eliminating the need for special brick shapes.

We call this Design Analysis—*where you use NBD's more than 80 years of engineering and casting background, plus our research and production facilities, to prove ideas and make a design practical.* This is NBD's heavy experience with blast furnace copper and bronze paying off for you.

Right now you may have an idea which needs only a slight twist to make it practical. NBD may provide the twist you need. Call or write us to talk about it.

Pattern equipment for all bosh plate designs and sizes is maintained at NBD's Meadville, Pa., plant.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARIN

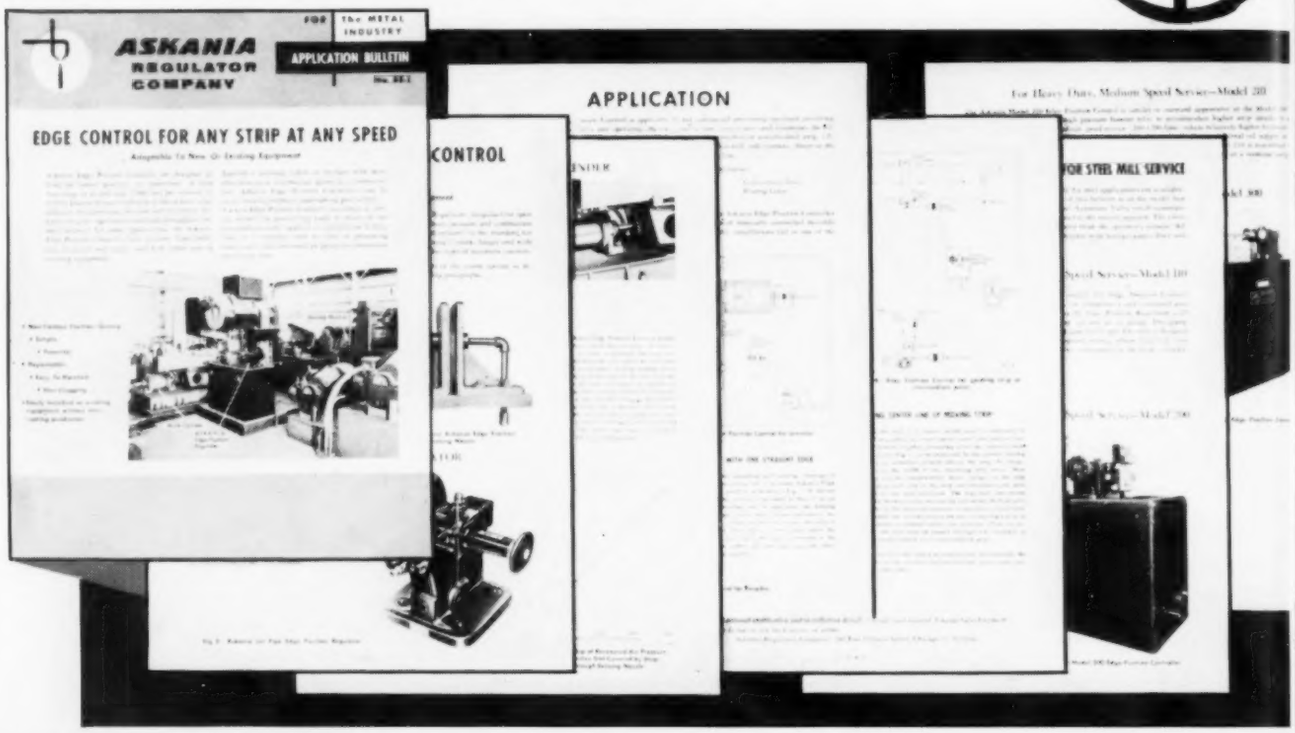
NBD VERTICAL-BAFFLE BOSH PLATE FEATURES

1. Vertical baffles enable positive inspection; assuring clean casting. Also permit faster water circulation.
2. Entrapped air expells through cored relief in top side of baffle at butt end of plate and the high outlet discharge.
3. Easy to backflush.
4. Uses standard brick shapes.

NOIVISION 4930 Manchester Ave., St. Louis 10, Missouri
Box 458 Meadville, Pennsylvania

Askania Regulator Company NEWS

***Automatic Controls for* COMBUSTION • PRESSURE**
FLOW • STRIP EDGE POSITION • STRIP THICKNESS



NEW BULLETIN DESCRIBES HOW AUTOMATIC EDGE CONTROL CAN BE INSTALLED ON NEW *OR EXISTING* STRIP LINE

Explains how it operates Accurately on *Any Strip* at *Any Speed*

ASKANIA REGULATOR COMPANY Bulletin No. 33.1 is now off the press and available to the Metal Industry. It describes performance advantages, applications, method of installation and control, and identifies the specific models from which to select.

It explains how these controls are designed to hold the lateral position (or centerline) of strip traveling up to and over 5,000 feet per minute...to within 0.030 inch of the desired edge position.

Well Illustrated

Bulletin 33.1 contains twelve special diagrams and illustrations. These emphasize the simplicity with which Askania Edge Position Controls are applicable to *any continuous processing operation* involving moving strip.

Some continuous applications are:

Pickling Lines
Annealing Lines
Cleaning Lines
Coating Lines
Slitting Lines
Trimming Lines
Galvanizing Lines
Plating Lines

Do you have these problems?

The four basic categories of Askania Edge Position Controls are explained in detail. These are:

1. Uncoiling strip for delivery at a constant edge position
2. Recoiling strip with one straight edge
3. Guiding strip at intermediate points along continuous lines
4. Guiding center line of moving strip

Are you familiar with these variations?

Model 110—For Light Duty, Medium Speed Service
Model 200—For Heavy Duty, Slow Speed Service
Model 210—For Heavy Duty, Medium Speed Service
Model 300—For Heavy Duty, High Speed Service

Inform Yourself

It pays to be informed—and Bulletin 33.1 contains the type of information you need. You'll be interested in facts proving the importance of simplicity...non-contact operation...ease of maintenance...non-clogging—easy installation, etc. as exemplified by ASKANIA EDGE POSITION CONTROLS.

Send for YOUR copy Today

Write Askania Regulator Company, 246 E. Ontario St., Chicago 11, Ill.

ASKANIA REGULATOR COMPANY
"CONTROLS FOR INDUSTRY"
HYDRAULIC, ELECTRONIC CONTROLS & SERVOS, GENERAL SYSTEMS, ENGINEERING & COMPUTER SERVICE, VALVE ACTUATORS & CYLINDERS

A SUBSIDIARY OF GPE

The world of science behind
EXIDE-IRONCLAD BATTERIES

Being interviewed is H. A. Fuggiti, Acting Senior Development Engineer

"Here's where the heavy slugs of power come from"

At the Exide Laboratories — **Reporter:** Just exactly what part of the battery is that, Mr. Fuggiti?

Fuggiti: This is the Exide-Ironclad positive plate. And in any battery, power reserve is governed by positive plate area.

Reporter: Then do you mean that Exide-Ironclad Batteries have *more* positive plate area?

Fuggiti: Exactly. You can see that here. The cylindrical power tubes are arranged in a row. So the semicircular sides give an effective plate area one-third more than the plate size.

Reporter: How does that increase power reserve?

Fuggiti: Because there's a bigger working surface of battery plate exposed to the electrolyte. Power response is faster.

Reporter: What does this mean in battery performance?

Fuggiti: It means the battery can provide power to spare for peak power loads as well as a dependable source for continuous loads.

Reporter: Obviously this is an important feature of the Exide-Ironclad Batteries.

Fuggiti: Yes it is, but it's just one of many engineering details that contribute to their long life and high capacity.

Note to battery users: Whenever you order heavy duty batteries or the equipment that requires them, be sure to specify Exide-Ironclad. For detailed bulletin, write Exide Industrial Division, The Electric Storage Battery Co., Philadelphia 2, Pa.

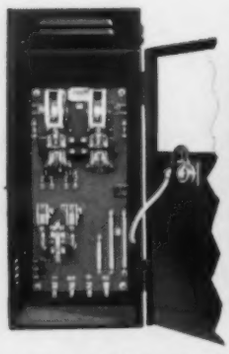
THE ELECTRIC STORAGE BATTERY COMPANY Exide®

Get more work from *any* magnet

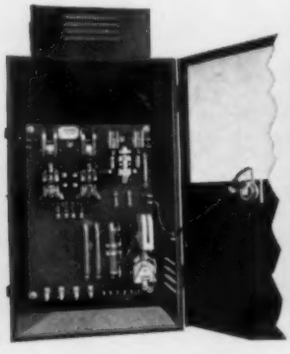
with EC&M MAGNET CONTROLLERS

ADJUSTABLE...for Faster, cleaner release of loads

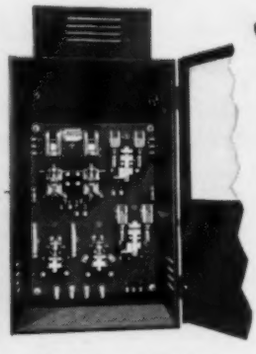
EC&M Magnet Controllers deliver top performance with magnets of all types and makes. They discharge loads quickly and cleanly. There is no "dribble." Magnets "work" more because faster drops eliminate "positioning" the magnet at point of discharge... A simple, two-position (Lift-Drop) Master Switch provides exceptionally easy operation. Because power is off, automatically, when the switch is in the "drop" position, there is no overheating to reduce high lifting capacity. Longer magnet life is another important bonus.



Type AD Standard Controller for single magnets or two magnets in parallel. Exclusive, adjustable discharge for different type loads



Booster Controller gives increased pull-away power from pile, then carries load at reduced current



High Speed Release DLM-335-A Controller reduces the discharge time of deep-type magnets 50%

***Bulletin 905** gives complete description of EC&M Controllers for use on lifting magnets of all types and makes*

***Write** for your copy*

THE ELECTRIC CONTROLLER & MFG. CO.

A DIVISION OF THE SQUARE D COMPANY

CLEVELAND 28 • OHIO

8017

Industry News...

PLANT EXPANSION PROGRAM AT GADSDEN ALA. TO BE ENLARGED BY REPUBLIC STEEL CORP.

▲ Republic Steel Corp.'s Gadsden plant expansion program will be enlarged by the addition of a second electric steelmaking furnace. The present Gadsden program is part of a huge expansion being undertaken by Republic at Chicago, Cleveland, Warren, Ohio, and Gadsden as well as several other locations. When completed late in 1957, the expansion will add 1,980,000 tons of annual ingot capacity to the Republic production facilities, bringing the total Republic capacity to 12,242,000 tons.

An electric furnace now being built will increase the plant's ingot capacity by 25 per cent in May. Addition of the second electric will make the total ingot increase approximately 50 per cent when it goes into production late in 1957, the company pointed out.

Present rated ingot capacity of the Gadsden plant with its eight open hearth furnaces is 789,000 tons annually. Each of the new electrics is rated at 204,000 tons annually. When both are in production, therefore, the Gadsden plant's capacity will jump to 1,197,000 ingot tons a year.

Currently, the new strip mill at Gadsden is nearing completion. By the time this mill is ready for production in mid-1957, it will have been approximately a two-year construction job. This mill will turn out hot rolled, cold rolled, and galvanized sheets and strip.

Several units besides the second electric furnace are called for in Republic's decision to proceed with a new phase of the expansion even before the completion of the original construction program.

These additional units include: a second new slab heating furnace for the plate mill. This furnace will have a capacity of 100 tons an hour, the same as a new furnace now being built as part of the original expansion program; two more blocks of soaking pits; an increase in the area of the sheet finishing and shipping departments, including the building of new warehouse space and truck loading docks; an addition to the machine shop and the electrical shop, a four-bay extension to the roll shop; a scale-breaker and scale flushing system to be installed at the plate mill; and additional railroad trackage, roadways, fire protection equipment, electric power distribution equipment, yard piping, sewers and drains.

SWEDISH MILL TO USE NEW OXYGEN PROCESS

▲ Stora Kopparbergs Bergslags A/B of Sweden will construct a steel mill of 475,000 tons capacity. The mill will utilize the Kal-Do oxygen converter process developed by the firm's American Subsidiary, of Stora Kopparberg Corp.

Two 80-ton rotating oxygen converters will be installed in the melt shop of the new mill, which will be as large as Stora Kopparberg's Domnarvet Works, as well as the government-owned steel plant at Luleo, Scandinavia's biggest steel mills.

This represents the first sale of the license for the new oxygen process, developed by Professor Bo Kalling of the Swedish firm.

The mill's rolling capacity will be about 330,000 tons annually of high quality ship and other plate.

DUQUESNE WORKS TO ADD NEW METALLURGICAL LAB

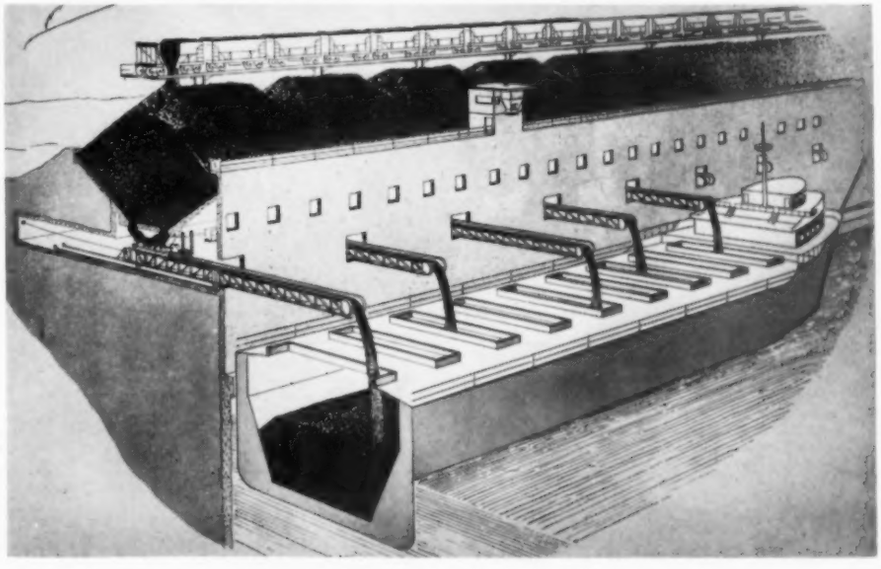
▲ United States Steel Corp. will build a new metallurgical laboratory at its Duquesne, Pa., Works.

The metallurgical laboratory will complete a two-phase program initiated by U. S. Steel to enlarge and modernize testing facilities at Duquesne, the first being a chemistry laboratory now in operation.

In addition to testing materials

CONVEYOR SYSTEM TO SPEED TACONITE LOADING

Cutaway drawing shows operation of a new system of 25 shuttle belt conveyors which will be used for the loading of taconite pellets at Erie Mining Co.'s Taconite Harbor, Minn., port facility on Lake Superior. The system permits the loading of as many as 10 alternate hatches simultaneously, a departure from the conventional method of loading ore vessels by chutes. The announcement was made by Link-Belt Co., designer and builder of the system. Two vessels can be loaded simultaneously and the complete system of shuttle belts for each vessel is operated from a central control tower. The pellets arrive at the dock in rail cars, are emptied into a storage bin and weighed as they are loaded into hatches. Each of the 25 conveyors on the 1200-ft-long dock is capable of loading taconite pellets at the rate of 750 or 1500 long tons per hour at belt speeds of 250 or 500 fpm.



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HIGH ALLOY CASTINGS FOR HIGH TEMPERATURE SERVICE

1700°f

Here's an Annealing Retort for 1700° F Service 35% Ni—15% Cr 30" Diameter 30' Long

Duraloy is the place to come for high alloy castings—for high temperature service, for highly corrosive service. Castings to your specifications are a Duraloy specialty.

We are equipped to do large and small work. We can turn out single static castings of 7 tons or more and single centrifugal castings up to about 4½ tons. On your next high alloy casting job, check with Duraloy!

Send for Bulletin No. 3354-G

THE DURALOY COMPANY

OFFICE AND PLANT: Scottdale, Pa.
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CHICAGO OFFICE: 332 South Michigan Avenue

produced in the plant, the Duquesne scientists and metallurgists will conduct research into production problems and product improvements to augment work being carried on at the U. S. Steel Research Center.

The new Duquesne laboratory will be operated under the supervision of R. W. Graham, general superintendent. Dr. B. R. Queneau, plant chief metallurgist, will be in direct charge of the laboratory.

GRANTED ADDITIONAL MANGANESE CONCESSION

▲ The British South Africa Co. has announced that Vanadium Corp. of America has been granted a large additional manganese concession in Northern Rhodesia. The concession, to be known as the Chilili East Manganese Area, comprises approximately 2460 square miles. The grant gives Vanadium the exclusive right to prospect and stake claims for manganese.

The property is located near the 200-square mile manganese concession purchased by Vanadium in September, 1955. That concession contains large tonnages of unusually high grade manganese ore which can be mined on a low cost basis. The output from limited areas of the smaller operation produces approximately one-half of the company's current requirements for manganese ore. Partial development of the smaller concession has proven reserves estimated as sufficient to meet for at least ten years the company's current needs.

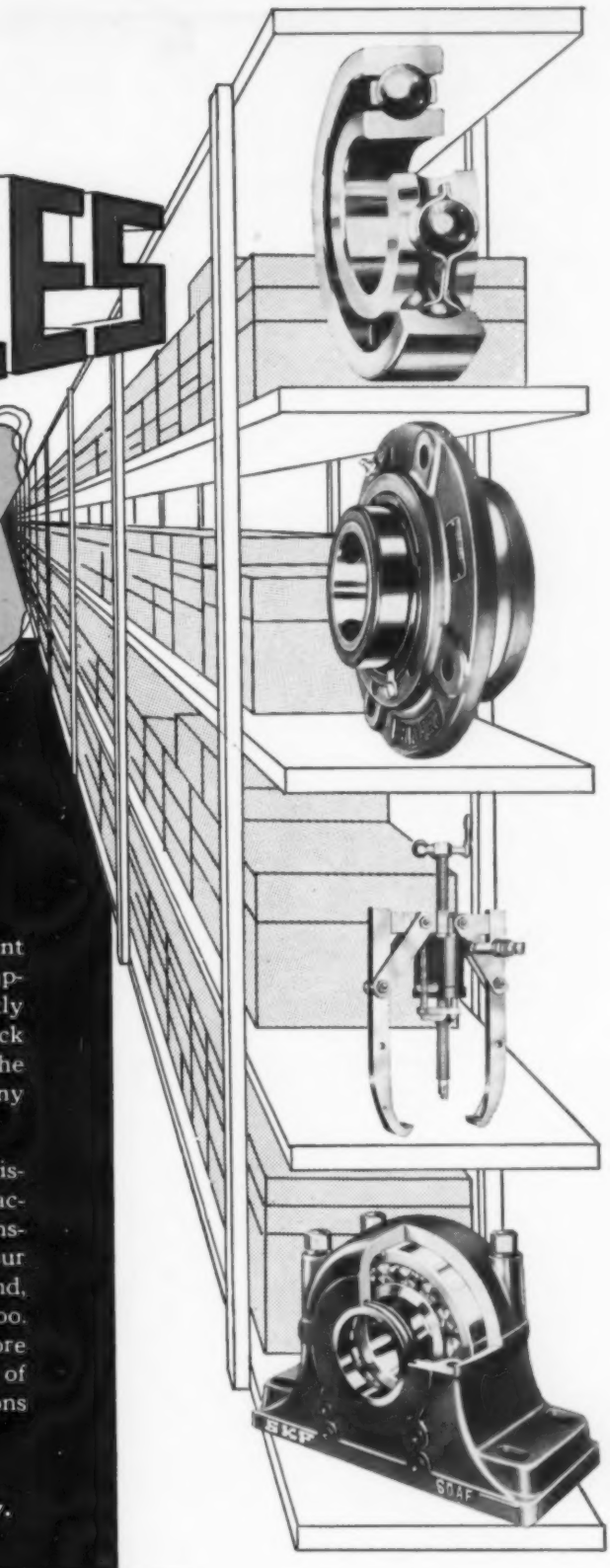
Geological work on the new concession will be staffed by the company's wholly owned subsidiary, Rhodesian Vanadium Corp. which operates also the company's chrome ore properties in Southern Rhodesia.

REACH AGREEMENT ON INFORMATION EXCHANGE

▲ A reciprocal agreement has been signed by Republic Steel Corp., covering the exchange of technical information in respect to steel developments with Kloeckner-Werke A. G. of Duisburg, Germany.

D. H. Bellamore, managing director of Republic Steel's International Projects Division, said that a separate agreement covers technical assistance to be rendered by Repub-

22 MILES OF SHELVES



With one of the largest and most diversified stocks in the U.S.A.--Berry Bearing can give you IMMEDIATE DELIVERY on anything you need!

Think of an assortment of 50,113 different bearings, bearing specialties, and transmission appliances. Then, imagine that assortment neatly stacked on over 116,160 running feet of stock room shelves. You'll then get some idea of the enormous inventory Berry Bearing Company regularly carries in stock.

Consequently, as authorized stock carrying distributor for 41 of the nation's leading manufacturers of bearings, bearing specialties, and transmission appliances--Berry can quickly fill your order for any type and any size you require. And, you can always bank on speedy delivery, too. Regardless of your address--you are now no more than 5 miles and 27 minutes away from one of Berry Bearing Company's six strategic locations in the Chicago area.

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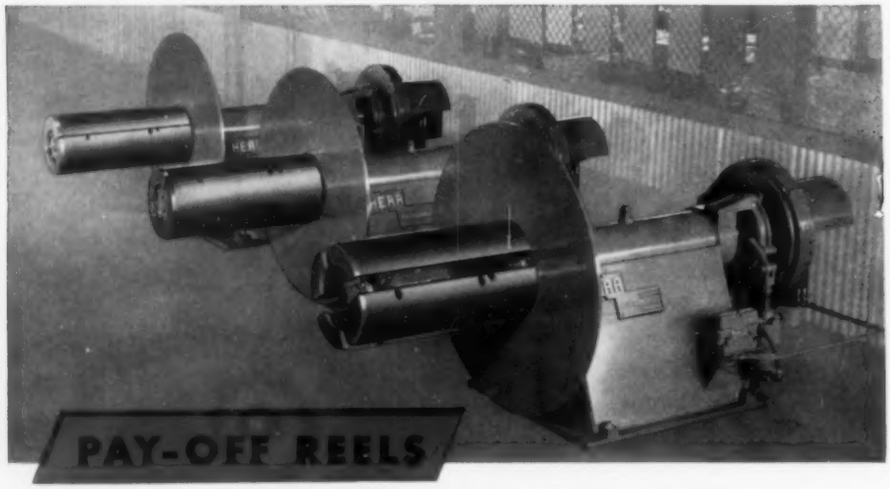
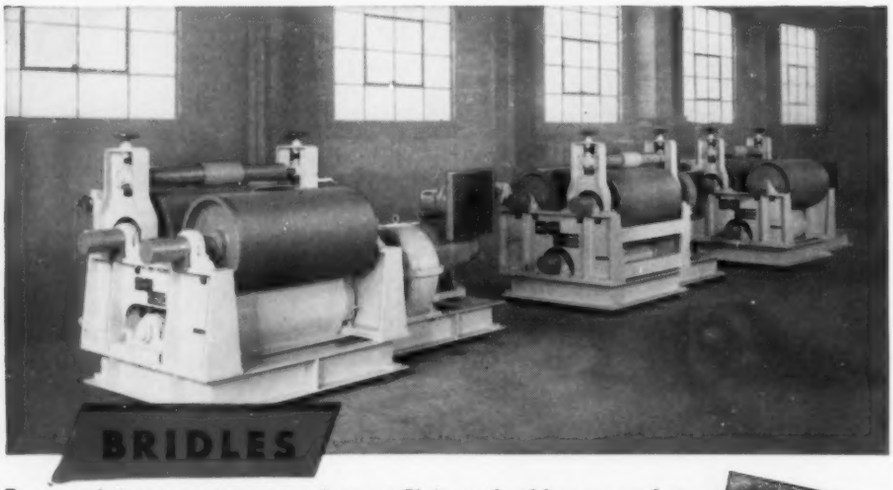
HERR EQUIPMENT

"Complete Processing and Handling Equipment . . . for any Ferrous or Non-Ferrous Material . . . That Starts — or Ends — as a Coil"



Types and sizes for coils weighing from 5,000 to 50,000 lbs. and up to 84" wide. Fixed, adjustable or automatically aligning bases. Timken bearings. Can be equipped with threading drive, also automatic speed compensating drive for feeding presses.



Types and sizes to meet any requirement. Plain steel, rubber covered or "Lorig" type self-aligning rolls. Air operated or regenerative brakes. Also four roll type that permits pay-off and coiling reels to be placed at the same end of the line and controlled with a single operator.

Write for fully descriptive Bulletin No. 561 today!

THE HERR EQUIPMENT CORPORATION

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CLEVELAND, INDIANAPOLIS AND BERKELEY, CALIFORNIA

lic to Kloeckner-Werke A. G. consisting of metallurgical and operational know-how for the new hot and cold rolling mills now being installed in the Bremen works of Kloeckner-Werke.

The Kloeckner-Werke A. G. also has many subsidiaries and manufacturing plants in Germany and foreign countries producing a wide variety of finished steel products. These include railway cars, locomotives, diesel trucks and tractors, mining equipment, and flotation equipment, industrial and smelting furnaces, and other highly developed steel products.

TO BUILD COKE OVENS FOR INDIANA HARBOR

▲ Koppers Company, Inc., was awarded a contract to design and build 174 Koppers-Becker combination coke ovens and auxiliary equipment at Inland Steel Co.'s Indiana Harbor works.

Two batteries of 87 ovens each will be erected. The new batteries will replace two existing batteries of 74 ovens each. The new ovens will be the gas gun type and will be designed for coke oven gas and future blast furnace gas underfiring. Koppers recently put into operation a battery of 87 Koppers-Becker coke ovens at the same site for Inland.

When the new batteries are completed Inland will have a total of 385 ovens at the Indiana Harbor #2 coke plant. Each new battery will carbonize 1870 net tons of coal per day.

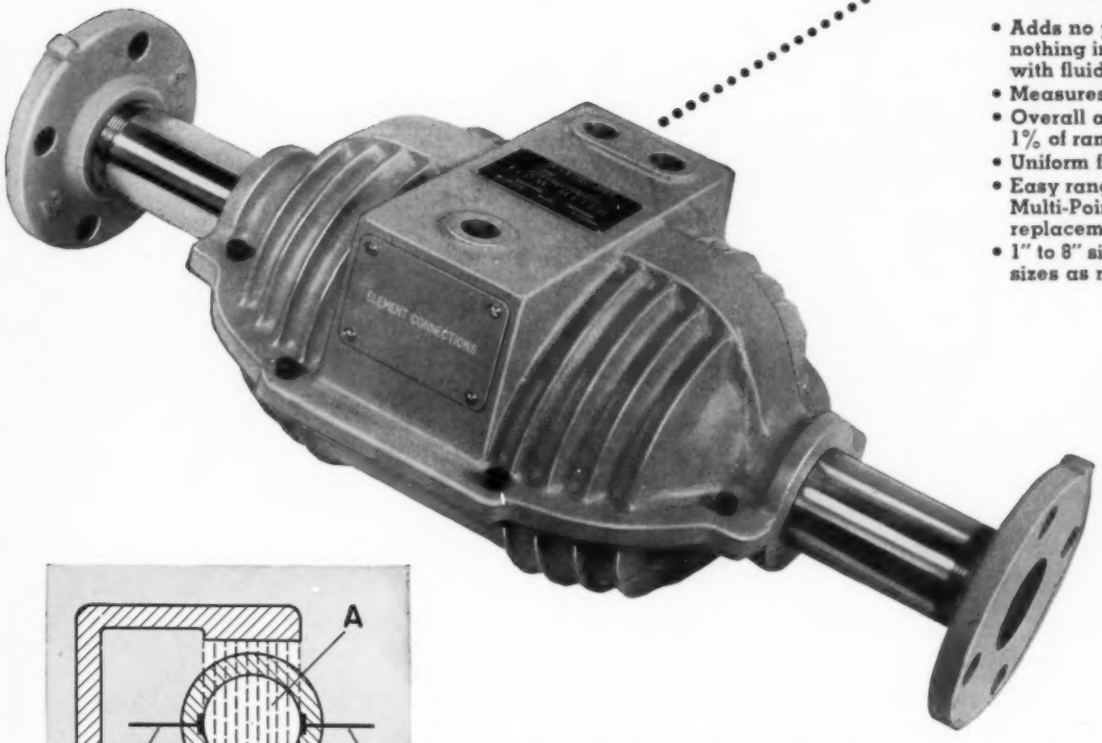
The new ovens are expected to be in operation the last half of 1958.

INITIAL ROLLING BEGINS AT RAVENSWOOD PLANT

▲ The first aluminum sheet is being rolled at Kaiser Aluminum & Chemical Corp.'s Ravenswood, W. Va., plant. Now in production are cold-rolling facilities, along with annealing furnaces, slitters, shears and other auxiliary equipment, for turning out light-gage sheet. The first foil mills are to start rolling shortly.

When completed, the rolling mill will have an annual capacity of 169,150 tons of fabricated products. The adjacent reduction plant initially will have four potlines with an annual capacity of 125,000 tons of primary aluminum, and enlarge-

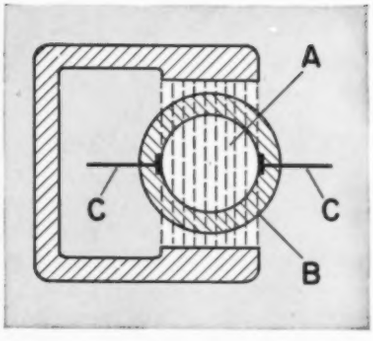
NOW! A flow meter for liquids other meters can't handle!



- Adds no pressure drop — nothing inside pipe to interfere with fluid flow.
- Measures fluid velocity directly.
- Overall accuracy better than 1% of range over entire scale.
- Uniform flow scale.
- Easy range change — either by Multi-Point Switch or range coil replacement, as preferred.
- 1" to 8" sizes standard — larger sizes as required.

. . . for liquids
water
acid
alkaline

. . . slurries of
sand
coal
waste
etc.



SIMPLE, TROUBLEFREE, OPERATION

The Foxboro Magnetic Flow Meter operates on the same principle as a power generator. A magnetic field (A) is maintained through a standard pipe section (B) of stainless steel or other non-magnetic material. This pipe section is lined with Kel-F® or other insulating material. Liquid passing through pipe acts as moving conductor, generating an electric voltage which varies in proportion to liquid's average velocity. Flush electrodes (C) in pipe wall "pick up" this voltage which is recorded in desired flow units by Dynalog Electronic Recorder or Controller.

The Foxboro Magnetic Flow Meter measures *magnetically* the flow rate of virtually any liquid except hydrocarbons. It completely ignores such common metering headaches as turbulence, suspended solids, and variations in conductivity, density, and viscosity. It even measures reversing flows.

Installation is simple. The magnetic spool piece connects into the line like any equivalent length of pipe — no seals, purges, meter runs, or straightening vanes required. Connects by simple electrical cable to remote Dynalog Electronic Flow Recorder.

Maintenance is practically eliminated. There are no pressure taps to become plugged or frozen, no working parts to foul. Find out how this precise, troublefree flow meter can help your operation. Write for complete details.

THE FOXBORO COMPANY, 582 NEPONSET AVENUE, FOXBORO, MASS., U. S. A.

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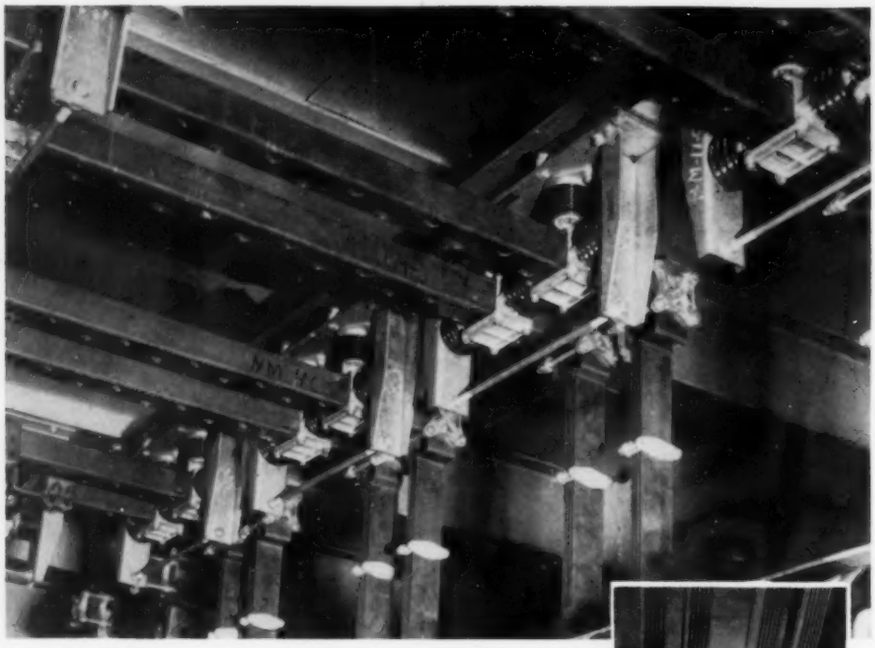
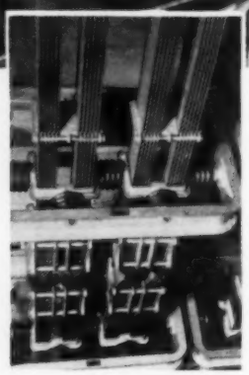
Foremost in FLOW METERING

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND





Avoid Costly Down Time

with DELTA-STAR reinforced

BUS STRUCTURES

When properly designed, bus structures can be relied on to withstand severe short circuits without damage. Delta-Star reinforced bus structures are engineered to withstand the maximum forces that may be encountered, consistent with the capacity of your system. Extra strength is built in by using heavy reinforced construction with high grade wet process porcelain placed in compression, taking full advantage of the porcelain's greatest strength.

Delta-Star engineers will be glad to work out your bus problems and develop a layout to suit your specific requirements.

OTHER DELTA-STAR PRODUCTS
Used in Mills and Industrial Plants

- Crane Rail Supports
- Disconnecting Switches
- Terminators (Potheads)
- Plugs and Receptacles
- Spool Insulator Cable Supports
- Water Cooled Conductors and Fittings
- Interrupter Switches
- Power Connectors

For complete information, see your Delta-Star representative.
Delta-Star Electric Division, H. K. Porter Company, Inc.,
2437 Fulton St., Chicago 12, Illinois

HKP DELTA-STAR ELECTRIC DIVISION
H. K. PORTER COMPANY, INC.

ment to a capacity of 220,000 tons is contemplated as the aluminum market warrants.

The cold-rolling facilities now in operation at Ravenswood are, for the present, using reroll stock from the corporation's plant at Trentwood, Wash.

In the building bays surrounding those containing the equipment in operation, work is being pressed toward completion of the 32-acre rolling mill and installation of the remainder of its facilities. Construction work is also progressing on the reduction plant.

It is expected that ingot casting facilities and the rolling mill's hotline will begin operation by the latter part of the summer, and that first metal will be poured from the first potline of the reduction plant at about the same time. Other potlines are expected to commence production at intervals of 2–2½ months.

GLOBE METALLURGICAL ACQUIRED BY INTERLAKE

▲ The merger of Globe Metallurgical Corp. with Interlake Iron Corp. was announced by R. W. Thompson, president of Interlake.

The merger had previously been approved by directors of both companies. It follows the acquisition by Interlake of more than 99 per cent of Globe stock, through exchange offers.

Globe Metallurgical, located near Beverly, Ohio, produces ferro alloys used primarily in the manufacture of stainless and alloy steels. Its name has been changed to the Beverly Plant of Interlake.

WELLMAN WILL BUILD ORE UNLOADER AT GARY

▲ A new Hulett ore unloader will be built by the Wellman Engineering Co. for the Gary, Ind., works of the United States Steel Corp.

The new unloader, which will have a rated capacity of 20 tons per bite, will be the ninth Hulett unloader Wellman has engineered and installed at Gary since 1906. The present installation includes three 20-ton machines built in 1942 and two 17-ton unloaders installed in 1915.

Wellman will provide complete engineering for the entire project and will build the mechanical com-

ponents. McDowell Co., Inc., Wellman's parent organization, will install the mechanical components and drives and deliver the unloader in going operation. The American Bridge Division of U. S. Steel will fabricate and erect the main structural framework.

ILLINOIS GEAR STOCK PURCHASED BY HUBBARD

▲ The sale of all of the outstanding stock in Illinois Gear & Machine Co. to Hubbard and Co. has been announced. There will be no changes in the management or policies of the company. Illinois Gear was founded in 1932 and is one of the nation's leading manufacturers of industrial gears for every purpose.

It was also announced that the company's expansion program has been stepped up. An additional new plant is being added to its South Works to accommodate new machinery estimated to cost $2,000,000.

REFRACTORIES FIRM OPENS ATLANTA OFFICE

▲ The Chas. Taylor Sons Co., a subsidiary of National Lead Co., announces the opening of a new district sales office at 5845 Greenbrier Road, Atlanta, Ga.

Manager of the office is Stafford T. Lantz, a field engineer for Taylor with 12 years' experience. States served by this office will be: Ga., Ala., Tenn., S. C., N. C., Miss. and Fla.

AIR PRODUCTS AWARDED GRANITE CITY CONTRACT

▲ A contract for the manufacture of an oxygen generator has been awarded to Air Products, Inc., by Granite City Steel Co.

Installation of the oxygen generator will be made in 1957. Air Products already has two generators installed at Granite City.

GERMAN FIRM OPERATING GIANT BLAST FURNACE

▲ Phoenix-Rheinrohr A.G. of Duesseldorf, West Germany, put a new 250-ft blast furnace into operation at its Ruhrort plant. The furnace cost $7,500,000 and took 16 months to build.

In the town of Ruhrort-

Keystone integrated aluminum conductor systems feature long life, minimum downtime, low installation costs, increased safety and high current capacity. Surrounding photo shows system being installed.

No winter downtime with Keystone Aluminum Conductor System

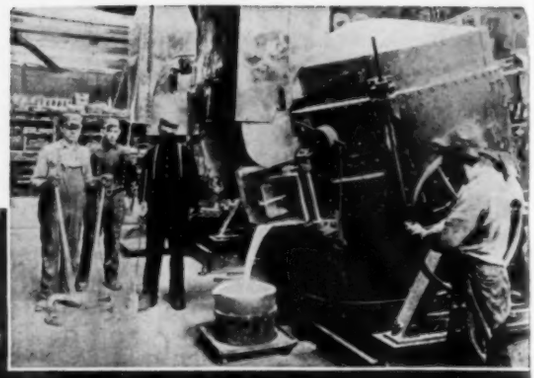
For two winters—and going into the third—Niagara Mohawk Power Company, Buffalo, has enjoyed trouble-free service with a Keystone integrated aluminum conductor system. The system replaced one of wire used with Niagara's traveling coal storage towers.

Service conditions are severe here. Ice is a big problem. Sulphuric acid fumes from coal piles cause corrosion. But with aluminum Inverted-V Keystone conductors and enclosures, these problems are solved.

Other advantages of Keystone integrated conductor systems improve operations indoors, too. Low voltage drop—rugged components—no wires to burn down. Steady operation is assured.

For further case history information and data on use of Keystone Aluminum Conductor Systems, call or write *Electric Service Works, Delta-Star Electric Division, H. K. Porter Company, Inc., Philadelphia 32, Penna.*

HKP ELECTRIC SERVICE WORKS
DELTA-STAR ELECTRIC DIVISION
H. K. PORTER COMPANY, INC.



The first Electric Brass Melting Furnace in America — built by The Electric Furnace Co., Salem, Ohio.

An EF combination electric and gas fired furnace installation in a prominent steel plant producing galvanized strip. This equipment flame cleans, uniformly anneals and galvanizes strip continously.

EF continues to pioneer

New Developments

for continuous and batch processing ferrous and non-ferrous products

From the company's beginning, when the little furnace shown above was "big news"; to the modern, completely automatic, high production strip lines, EF research and development engineers have been making important contributions to furnace design and metal processing techniques.

EF engineers conceived and developed the first automatic and continuous heat treating, quenching and drawing equipment; pioneered the use of endothermic, exothermic and other special atmosphere treatments resulting in closer physical tolerances.

Other developments include EF radiant tubes with heat exchangers that assure extremely high combustion efficiency; EF cast alloy electric heating elements; EF roller design—and other facilities that assure uniform temperatures throughout the furnaces, accurate control of heat input, reduced maintenance and high hourly output.

For maximum product uniformity, dependability and efficiency, discuss your heating problems with EF experienced engineers . . . it pays.

EF **THE ELECTRIC FURNACE CO.**

GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

Salem - Ohio

Canadian Associates • CANEFCO, LIMITED • Toronto 1, Canada

Meiderich, Phoenix-Rheinrohr A.G. has now 13 furnaces. Through this addition, the capacity will be increased by 30,000 tons of crude iron per month. This latest expansion makes Phoenix-Rheinrohr A.G. the largest crude iron manufacturer in West Germany, with an average monthly production of more than 200,000 metric tons.

H. K. PORTER ACQUIRES REFRACTORIES COMPANY

▲The Mullite Refractories Co., Shelton, Conn., has been acquired by H. K. Porter Co., Inc. It will be combined with Porter's Lacelede-Christy Division.

The Mullite Co. refractory products are trade named "Shamva" mullite. Products now manufactured include a regular mullite brick for the steel industry. Other products include ramming, mortar and castable cements; a plastic fire brick cement used for building up monolithic structures or for repairing or patching electric furnace roofs; and flat arches for any furnace construction.

Porter's other refractory division is McLain Fire Brick with headquarters in Pittsburgh. Lacelede-Christy's headquarters are in St. Louis.

KAISER PURCHASES WIRE AND CABLE BUSINESS

▲Kaiser Aluminum & Chemical Corp. has announced purchase of the wire and cable business of the United States Rubber Co.

The purchase, for an undisclosed amount in cash, was effective February 1 and includes U. S. Rubber's insulated wire and cable plant at Bristol, R. I., and its wire and cable inventories, according to the announcement made by D. A. Rhoades, Kaiser Aluminum vice-president and general manager.

In addition, Kaiser Aluminum takes over U. S. Rubber's nationwide wire and cable sales organization and network of distributors as well as all Bristol plant personnel. The corporation plans to continue service without interruption to existing customers and maintain the same channels of distribution.

The U. S. Rubber Co. has manufactured wire and cable at the Bristol plant since 1892. The plant is located on an 18-acre site in Bristol, approximately 15 miles south of Providence, R. I. It includes several buildings totaling 654,000 sq ft of floor space.

Currently Kaiser Aluminum is also carrying out a $5,000,000 expansion of rod, bar and wire facilities at its Newark, Ohio, plant.

EUROPEAN SUBSIDIARY FORMED BY SELAS CORP.

▲Formation of a European subsidiary known as Selas Corp. of America, European Division S. A., with headquarters in Geneva, Switzerland, has been announced by Frederic O. Hess, president, Selas Corp. of America.

The new firm, which will ser.e industries throughout Western Europe, is an outgrowth of increasing interest in Selas developments and equipment for industrial heat and fluid processing of materials.

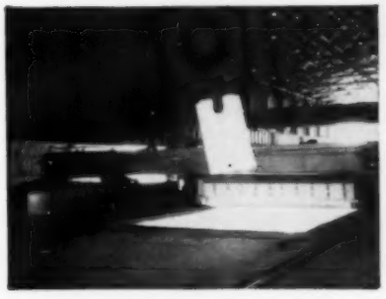
Six leading European companies have already acquired licenses to Selas processes and know-how, and it is the objective of the Swiss division to give these licensees prompt, efficient attention and to coordinate engineering and administration be-

(*Please turn to page 220*)

Open Hearth Furnaces—Photo Courtesy Jones & Laughlin Steel Corp.

Continuous Heating Furnaces—Photo Courtesy Crucible Steel Co.

Soaking Pit—Photo Courtesy United States Steel Corp.



Heat Treating Furnace—Photo Courtesy Taylor Forge & Pipe Works

Increase Production . . . Lower Production Costs with

LOFTUS Industrial FURNACES

For years Loftus Industrial Furnaces have been providing dependable, economical service to the steel industry. Their long life and efficient performance have been proved by time. The fact that they materially contribute to lower-cost operation and increased production is a matter of record.

Whatever your heating, melting or heat-treating requirements, it will pay you to take advantage of Loftus' long experience in furnace design and construction. Many of the world's leading companies have—and to their utmost satisfaction, as proved by the high percentage of repeat orders we get.

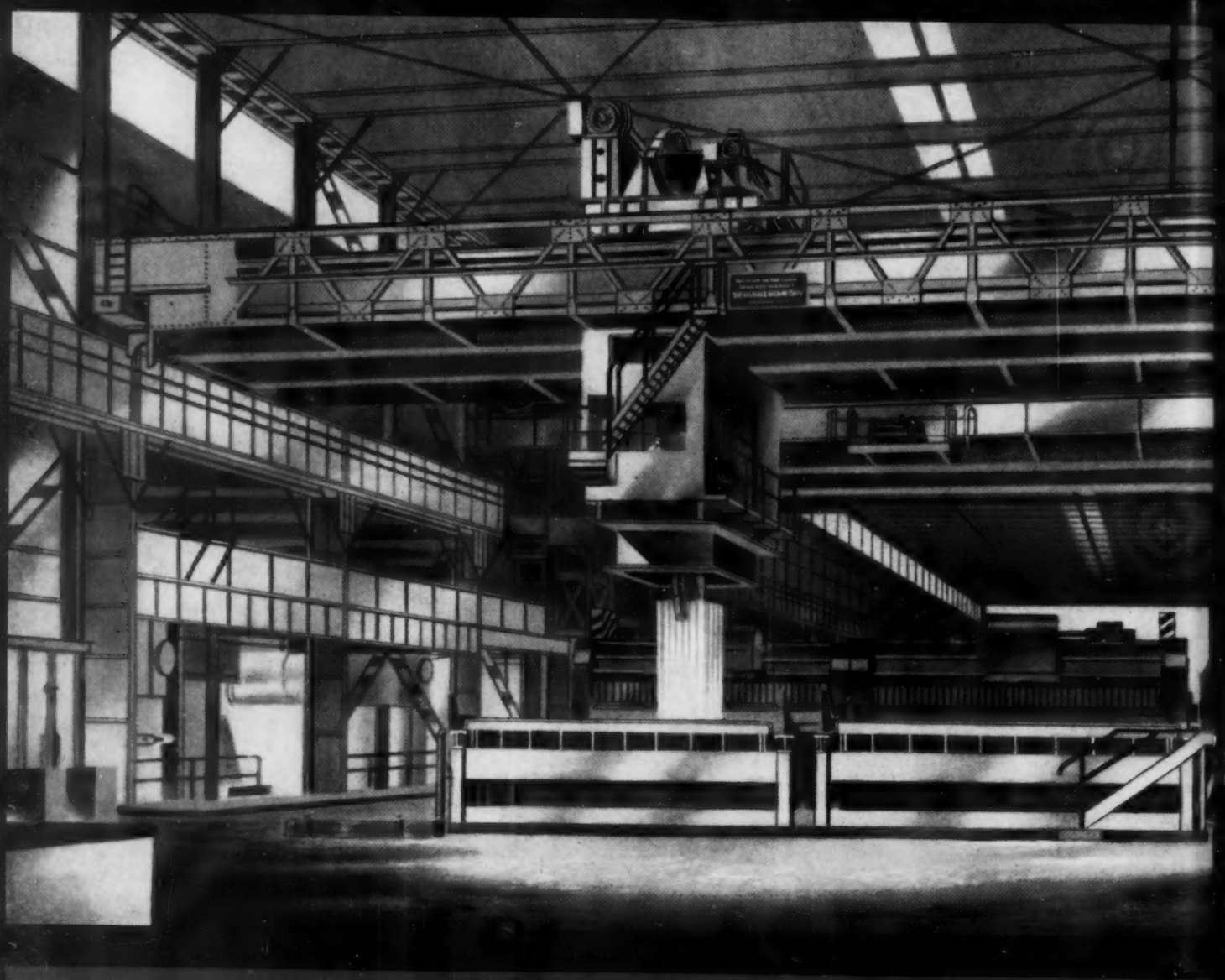
We'll be glad to send you full details and we will welcome an opportunity to quote on your requirements.

Designers and builders of industrial furnaces

LOFTUS *Engineering Corporation*

610 Smithfield St., Pittsburgh 22, Pa.
140 S. Dearborn St., Chicago, Ill.

INTENSIFIED GRIP..



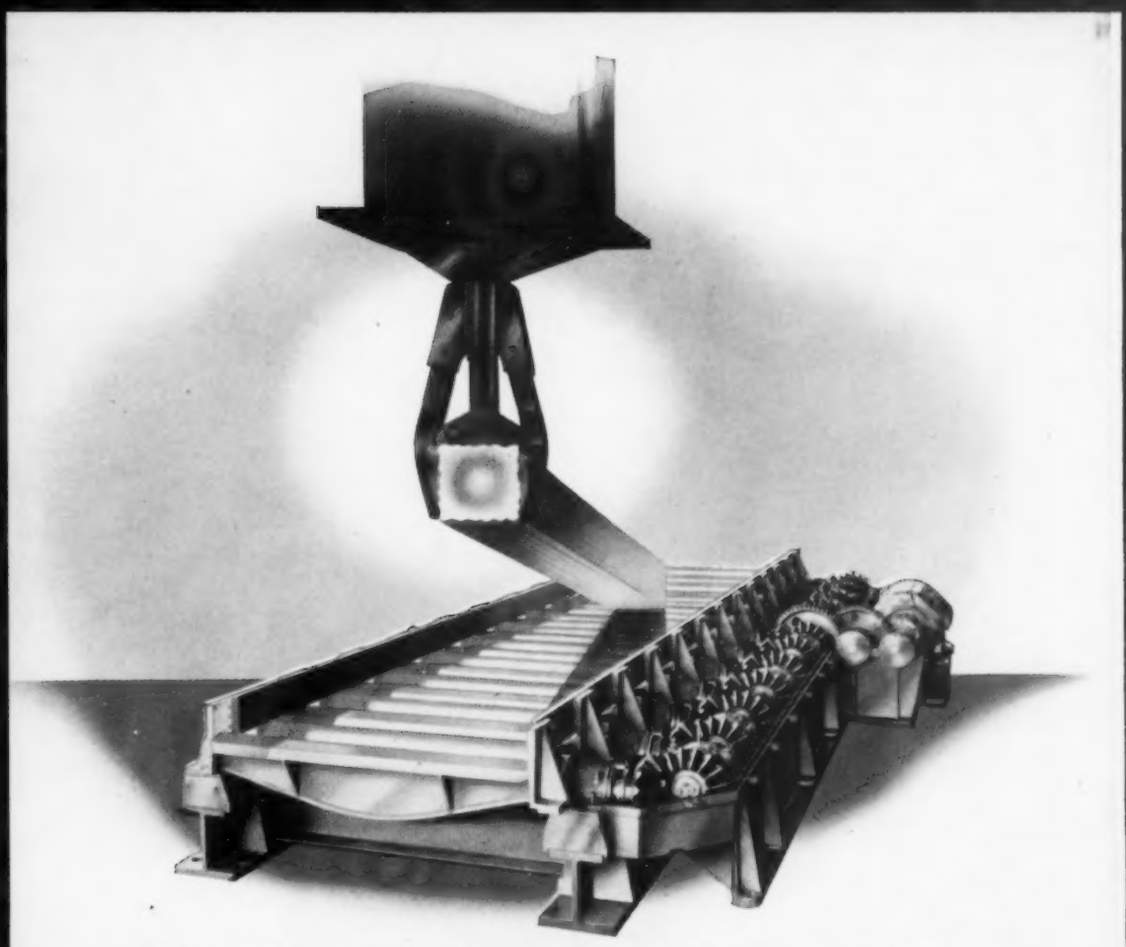
The tong grip of the conventional soaking pit crane depends *solely* on the weight of the ingot and when the weight of the ingot is removed, as in the case of placing an ingot on an approach mill table, the grip is reduced to zero and the ingot drops.

The tongs' grip of the Alliance intensified grip soaking pit crane is produced by the weight of the column *plus* the weight of the ingot. Since the weight of the column is usually equal to the weight of the ingot, the intensified grip soaking pit crane has the same grip *without* an ingot in the tongs as a conventional soaking pit crane has with an ingot, and *twice as much grip* as the conventional soaking pit crane when handling an ingot.

These intensified grip soaking pit cranes are built to handle ingots of any size and weight and incorporate all modern safety features. We welcome the opportunity to assist in solving your material-handling problems.

THE ALLIANCE MACHINE COMPANY

or Soaking Pit Cranes



The intensified grip soaking pit crane was developed by The Alliance Machine Company to hold ingots more firmly in the tongs and prevent dropping of ingots when they are placed on the mill approach table, ingot chariot or in the soaking pits. This is an exclusive Alliance feature.

Alliance

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION

MAIN OFFICE • ALLIANCE, OHIO

THE WORLD'S LARGEST BUILDER OF THE WORLD'S LARGEST CRANES

(*Continued from page 217*)

tween these and future licensees and the Selas home office in Dresher, Pa.

Heading the Swiss Selas Corp. is W. Jack Hofmann, general manager, with A. E. Baltus, who has been general European representative for Selas the past seven years, as sales manager.

SHARON STEEL BUILDS NEW ELECTRIC FURNACE

▲The first spadeful of dirt, starting construction on a new $6,000,000 electric furnace facility at the Roemer Works in Farrell, Pa., was turned on January 29, by James A. Roemer, vice president of Sharon Steel Corp.

When the new furnace goes into operation next year, it will more than double the present 72,000-ton annual capacity of electric-furnace steel at Sharon. Output from the new furnace will go into high-alloy, high quality stainless and specialty steels.

At the same time that the new furnace is being built, foundations will be laid for a second new electric furnace which can be installed at a later date.

The new furnace has a yearly capacity of 72,000 tons with individual melts of 80 to 100 tons. The furnace will be housed in a building 250 by 280 ft.

Expected date of starting operations is January 1958. Design, engineering and construction is by American Bridge Division of U. S. Steel Corp.

TO BUILD NEW PLANT AT WELLINGTON, OHIO

▲Armco Drainage & Metal Products, Inc., has announced plans to build a new $400,000 manufacturing plant at Wellington, Ohio.

The announcement was made by S. R. Ives, president of Armco Drainage, who said that the new plant would be the 54th in a chain of Armco Drainage plants scattered throughout the U. S. and Canada. The company is a subsidiary of Armco Steel Corp., and produces a wide variety of metal pipe steel buildings, and other steel products used in the construction industry and on the farm.

The new plant will manufacture corrugated metal pipe and pipe arches, paved pipe and pipe arch, large diameter sewer pipe, and pipe fittings. It will also serve as a warehouse for Armco drainage products manufactured elsewhere.

A. C. Neff, vice-president of Armco Drainage, and head of the company's Central Division, will be in charge of building and operating the plant. Project engineer will be C. E. Hattery, production supervisor of the Central Division.

COMPLETES TRANSFER OF PRESS OPERATIONS

▲Baldwin-Lima-Hamilton Corp. has completed transfer of the manufacturing and sales operations of its hydraulic and compacting press department from the Eddystone Division, near Philadelphia, Pa., to the Hamilton Division, Hamilton, Ohio.

The operations have been integrated with those of the mechanical press department which has always been in Hamilton.

The hydraulic press department is now in normal production.

SAVE downtime for bearing replacement

use A-B-K* bearings

A-B-K bearings won't peen, score or heat check your heavy roll and spindle parts, sharply reduce downtime and maintenance costs per ton rolled. Made of laminated phenolic fabric, they have the ability to absorb and cushion heavier impacts—and often outwear metal bearings many times. When replacements *are* necessary, downtime is reduced because A-B-K bearings have fewer parts, are lighter in weight, easier to handle. Ask our engineers for specific recommendations.

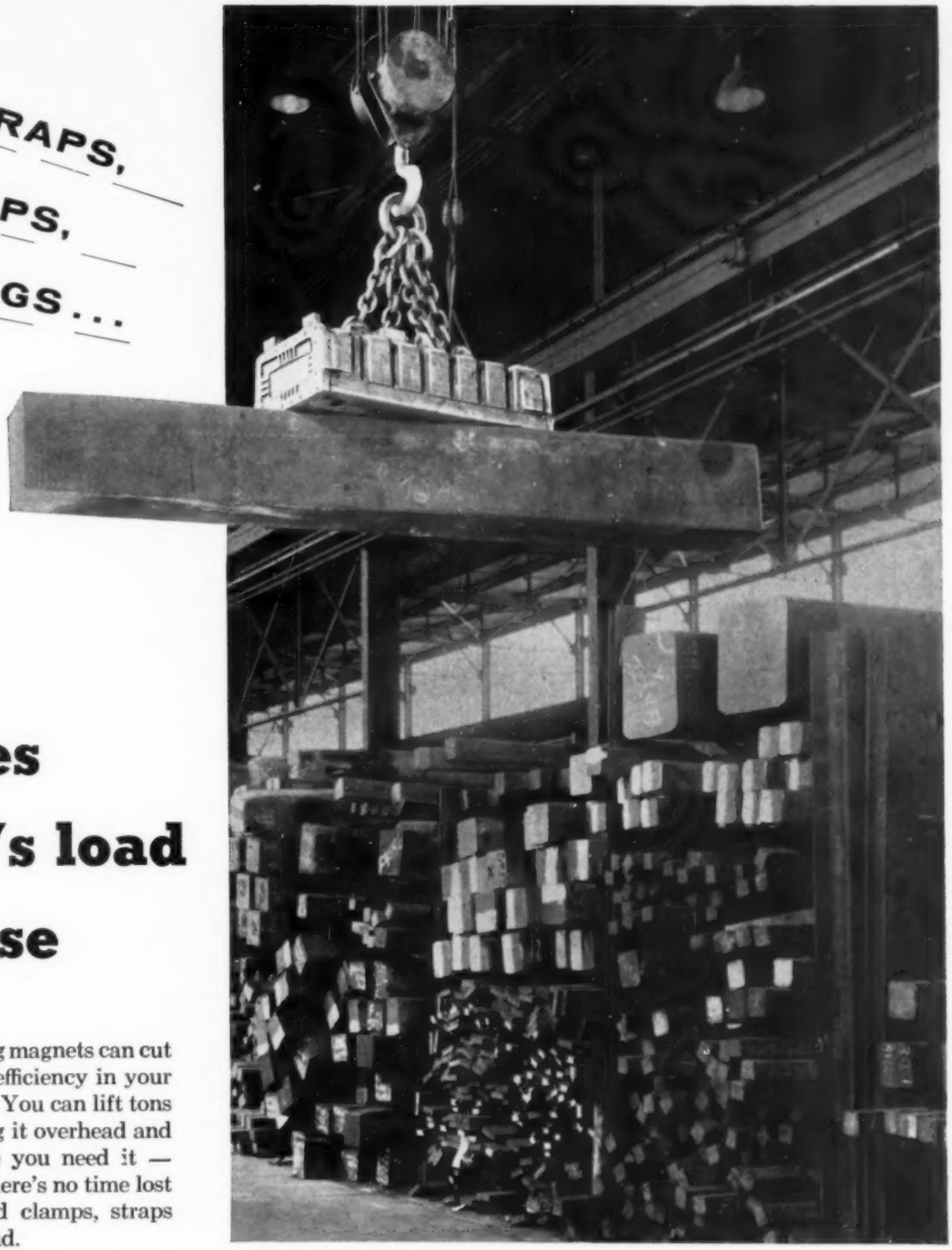
- Wear longer
- Won't score
- Light in weight
- Cut lubricant costs
- Save power

A-B-K
LAMINATED
PHENOLIC BEARINGS

*A registered trade-mark of American Brake Shoe Company

American Brake Shoe Company
American Brakeblok Division
DETROIT 9, MICHIGAN

NO STRAPS,
NO CLAMPS,
NO SLINGS...



yet it carries a giant's load with ease

Stearns rectangular lifting magnets can cut handling costs, increase efficiency in your stock-moving operations. You can lift tons of steel billet stock, swing it overhead and deposit it exactly where you need it — accurately and safely. There's no time lost in fussing with awkward clamps, straps or slings to secure a load.

To pick up a lift, the crane operator moves a control lever and instantly the powerful magnetic force reaches deep into the body of the load, clasps the iron burden and holds it — even though only a small surface area actually contacts the magnet itself during the move.

Once the material is delivered, the operator simply cuts the coil current to de-energize the magnet, immediately releasing the load with perfect control.

Ideal for handling regular shapes—sheets, plates, round or square bars, billets, ingots, pipe or boxed iron goods — Stearns rectangular lifting magnets have helped to speed material handling in many industries. Besides substantial savings in time and labor, magnetic handling permits better spotting of heavy lifts, higher tiering of stock to save valuable space.

Stearns builds both rectangular and circular lifting magnets for practically any application, with capacities to match your requirements. Write today for free literature. Ask for Bulletin 35-CI. 23

STEARNS MAGNETIC PRODUCTS

A DIVISION OF THE INDIANA STEEL PRODUCTS COMPANY • VALPARAISO, INDIANA

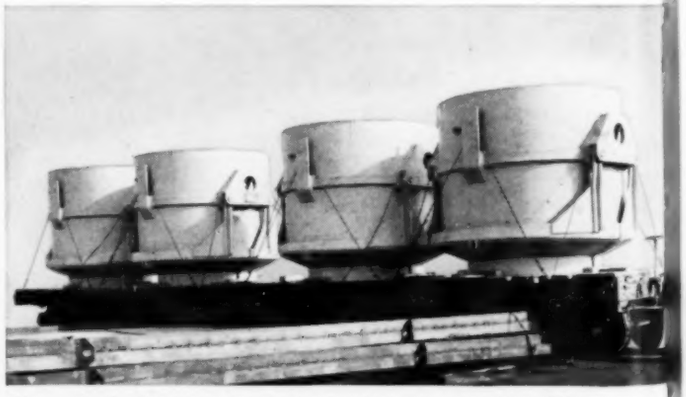
635 South 28th Street • Milwaukee 46, Wisconsin

STEEL PLATE *Fabricating Facts!*

McGREGOR-MICHIGAN Brochure Describes Diversified Facilities and Production

In this compact 12-page brochure you'll find valuable information on McGregor-Michigan's equipment and typical steel plate fabrications. It shows scenes in our new 30,000 square foot Heavy Fabricating Plant and our original Rivard plant. It describes some of our new equipment including a 650 ton press brake and our 600 ton "Bulldozer" horizontal forming press capable of forming heavy beams or solid sections. In addition you'll find clear illustrations of steel plate fabrications for the primary metal producers—ladles, buckets, hooks, doors, water-cooled roof rings and others—and equally interesting chemical and petroleum processing equipment—ASME Code vessels, autoclaves, heat exchangers, kettles and tanks. Many of these assemblies run to 50 tons and over, in mild, stainless and alloy steels. Typical miscellaneous industrial fabrications shown are engine beds, bases for machines, jigs and fixtures, heavy-wall cylinders, foundry cupola shells, furnace casings, a self-propelled sewer tunnel shield and a heavy boom for a power shovel. The brochure also describes our plate warehousing and specialized surface treating services.

We would appreciate your including this informative booklet in your file of fabricating sources. Please send for a copy and the name of our representative nearest you or call direct for prompt service on any steel plate fabricating problem.



Clam shell charging buckets destined for leading West Virginia aluminum plant.

SINCE 1841

McGREGOR-MICHIGAN CORPORATION

5820 RIVARD • DETROIT 11, MICHIGAN

TRINITY 2-2400

STEEL PLATE FABRICATING AND WAREHOUSING

Capacities of presses manufactured now at Hamilton range from 30 to 10,000 tons.

NEW COMPANY FORMED FOR MELTING ZIRCONIUM

▲A new company, Reactive Metals, Inc., has been formed by Mallory-Sharon Titanium Corp., and National Distillers Products Corp. Ownership of the new company will be divided equally between the two parents.

The new firm will be initially engaged in the melting of zirconium and its alloys, and the manufacture of certain zirconium mill products, with physical facilities to be constructed at Ashtabula, Ohio, site of National Distillers' zirconium sponge plant. Production by the new company may later be expanded to include other metals of value to the atomic energy program, such as hafnium, columbium, thorium, etc.

Reactive Metals, Inc. will be operated independently of Mallory-Sharon's present activities in the titanium field and the National Distillers', U.S.I. Division manufacture of titanium and zirconium sponge.

Meetings

▲ Eight technical sessions will be given by American Society for Metals at the 10th Western Metal Congress, Mar. 25–29 in the Ambassador Hotel, Los Angeles, Calif.

Other societies to hold technical sessions will be the American Welding Society, Society for Nondestructive Testing and American Institute of Mining, Metallurgical and Petroleum Engineers—Metals Branch.

▲A group of 94 speakers will address the annual Spring meeting of the American Welding Society when it meets in Hotel Sheraton, Philadelphia, April 8–12, in conjunction with the annual Welding Show. The show will be held April 9–11 at Convention Hall.

For the first time, the American Institute of Electrical Engineers will join the society in sponsorship of some of the sessions. The institute's Committee on Electric Welding will be co-sponsor of two sessions on resistance welding and one on arc welding.

Protects Metals at Red Hot Temperatures!

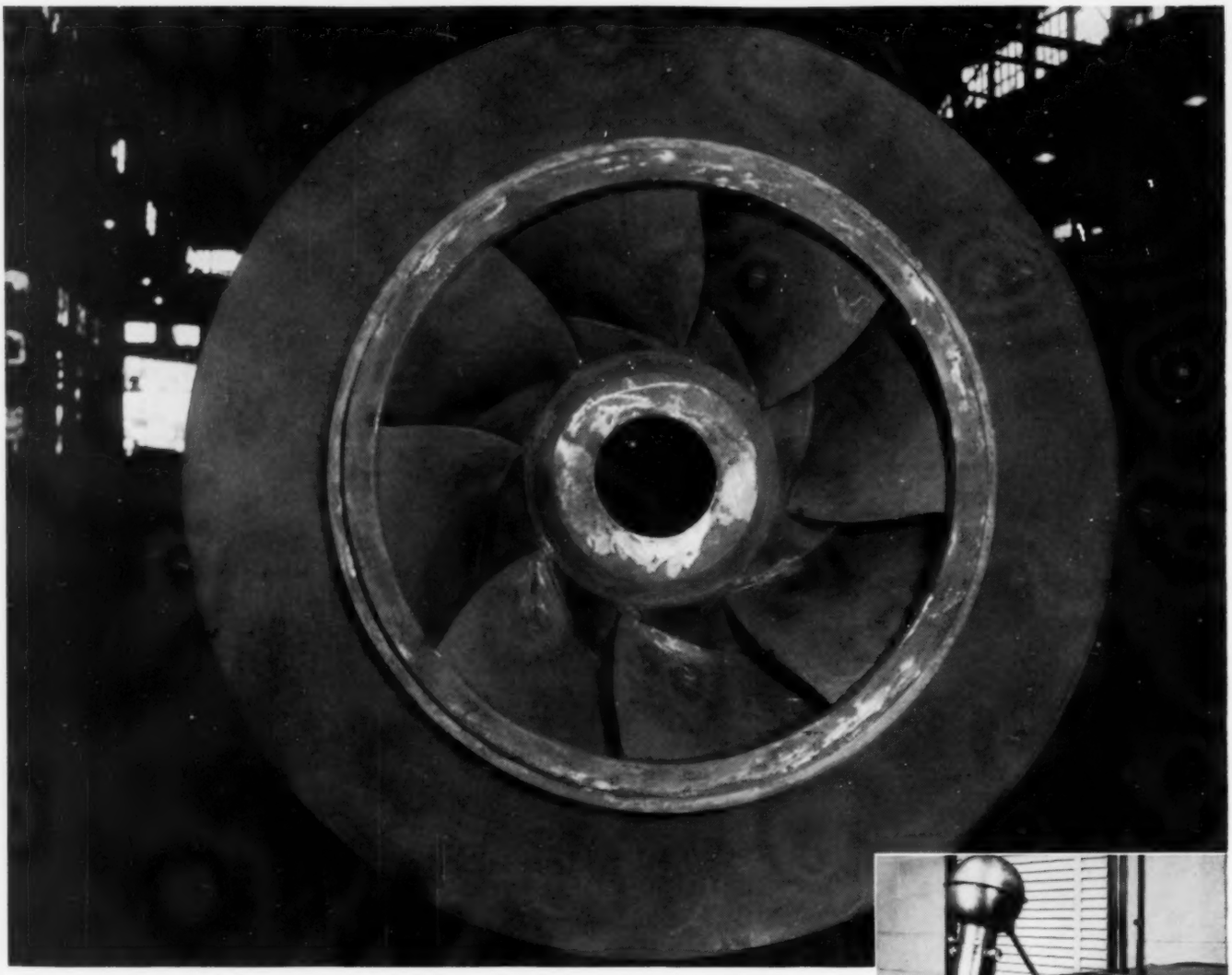
UP TO 2200°F

Heatproof Coating Stops Corrosion, Scaling and Oxidation

MARKAL "S-R" Coatings were developed to protect metals, graphite or carbon parts against scaling, corrosion, oxidation, or carbon and hydrogen penetration at temperatures up to 2200°F. MARKAL "S-R" Coatings are excellent for the protection of stacks, radiant tubes, retorts, carburizing grids, mufflers, manifolds, etc.

MARKAL "S-R" Coatings will not peel or crack at high temperatures and are not affected by rapid heating and cooling cycles.

MARKAL Coatings are manufactured in a complete range of types for specific applications. Write for a free copy of Catalog MPC. The **MARKAL COMPANY**, 3087 W. Carroll Ave., Chicago 12, Illinois.



Pump runner weighing 11,000 lb. and cast of Composition "G" at Baldwin-Lima-Hamilton's Eddystone Division. This special Baldwin alloy, 87.5% copper, 8% tin, 4% zinc and .5% nickel, has a tensile strength of 50,000 psi. It is extensively used for shaft liners, bushings, air valves, pump cases and covers, impellers, and valve bodies.

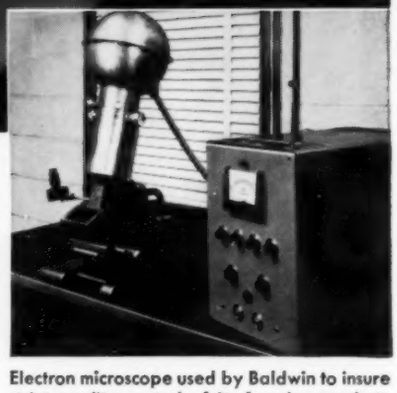
Hub section of 11,000 lb. pump runner cast by Baldwin passes inspection of 1,000,000-volt X-ray unit

When Baldwin makes your castings, you know you get precisely what you specify. The hub section of this 11,000-lb. pump runner for the Byron Jackson Company, Los Angeles, Calif., went under the penetrating eye of Baldwin's 1,000,000-volt X-ray unit and was conclusively proved to meet the specifications.

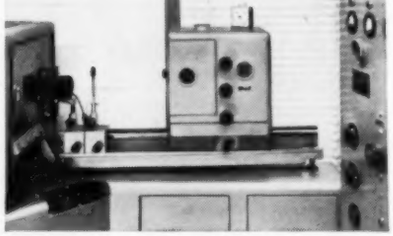
Made of Baldwin's own Composition "G," this runner was cast in cement bonded molds, which assure greater accuracy of pattern and minimum cleaning in the vane sections.

B-L-H's Eddystone and Standard Steel Divisions have both the skills and the facilities to produce any casting you need. So whatever your casting problem, you can turn to Baldwin with complete confidence.

For a copy of our illustrated Foundry Bulletin 6002, write to B-L-H Corporation, Philadelphia 42, Pa.



Electron microscope used by Baldwin to insure strict quality control of its foundry products where specified.



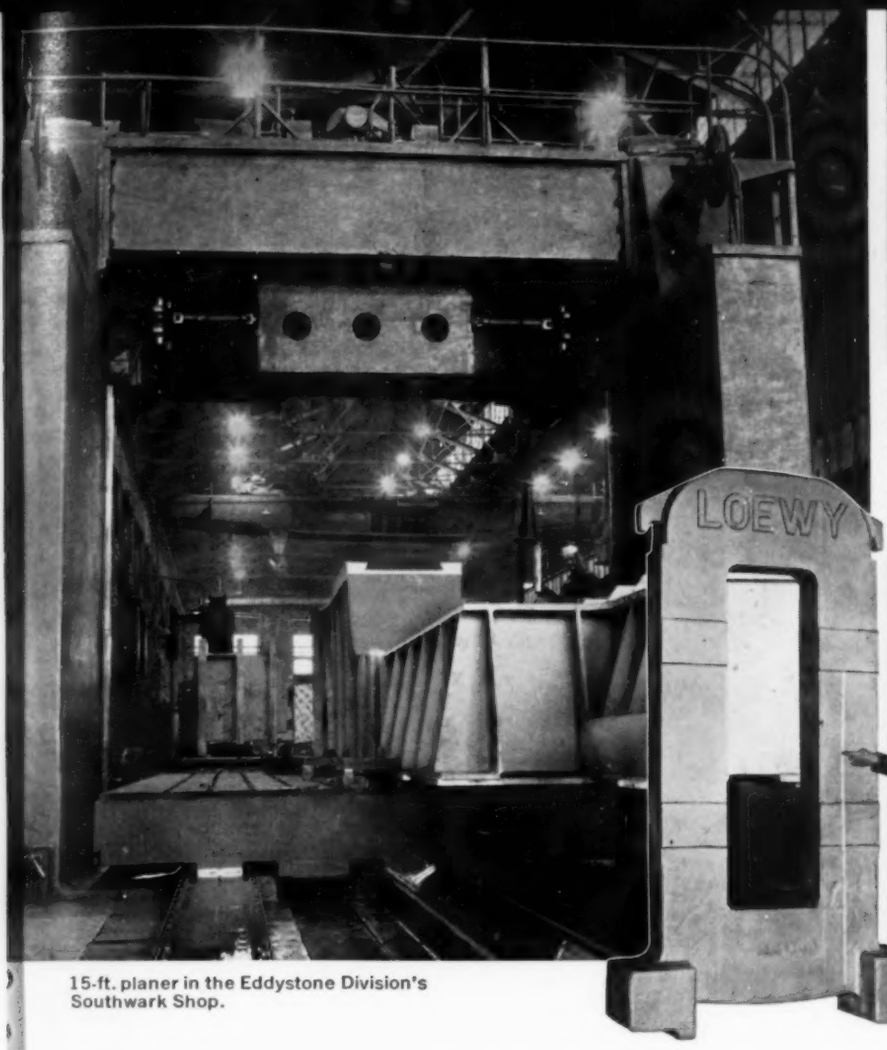
The spectroscope is also in wide use at Baldwin. It has proved invaluable in many research projects dealing with nonferrous castings.

BALDWIN · LIMA · HAMILTON

Eddystone Division

Philadelphia 42, Pa.

Hydraulic turbines • Weldments • Dump cars • Nonferrous castings



15-ft. planer in the Eddystone Division's Southwark Shop.

General Machine Shop at the Eddystone Division, Eddystone, Pa., whose 1,500,000 square feet of manufacturing space includes huge fabrication shops and a nonferrous castings foundry.

•

Blooming an ingot at the Standard Steel Works Division, Burnham, Pa., under one of the 2500-ton hydraulic presses.

Vast, integrated Baldwin-Lima-Hamilton facilities enable Loewy-Hydropress to deliver your rolling mills on time

When Loewy-Hydropress designs and builds your rolling mills, you aren't plagued by the usual troublesome and expensive delivery delay. For Loewy has at its disposal the vast, yet smoothly integrated resources of the entire Baldwin-Lima-Hamilton Corporation.

The two B-L-H divisions called upon most frequently to make parts for Loewy-designed rolling mills are the Standard Steel Works and Eddystone Divisions. The necessary steel components are cast or forged at Standard. And Eddystone, with its extensive machining facilities, supplies the completely finished nonferrous castings and weldments. Other members of the B-L-H family with excellent facilities for producing rolling mill parts are the Hamilton Division, Hamilton, Ohio; the Austin-Western Division, Aurora, Ill.; and the Madsen Division, La Mirada, Calif.

Close coordination among all Baldwin-Lima-Hamilton divisions is the chief reason why Loewy-Hydropress can deliver your rolling mills faster.

To your individual production requirements, we design, build and install hot and cold rolling mills for ferrous and nonferrous metals, continuous merchant and wire-rod mills, skelp mills, two-high and three-high blooming mills, high-speed foil mills, continuous billet and sheet-bar mills, strip, slabbing, plate, structural, rail mills, and special mills. Write us today, Dept. C-2, for illustrated bulletin L-164.

Loewy-Hydropress designers at the company's headquarters in New York City.

Loewy-Hydropress Division

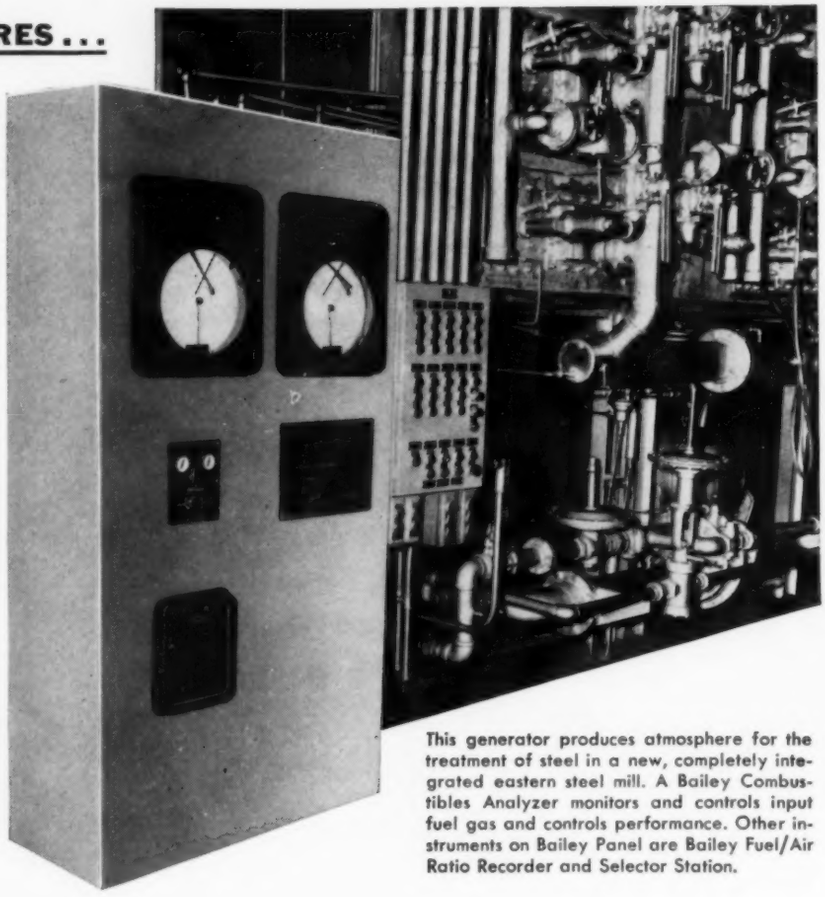
BALDWIN · LIMA · HAMILTON

111 FIFTH AVENUE, NEW YORK 3, N.Y. Rolling mills • Hydraulic machinery • Industrial engineering

BALDWIN BLH LIMA-HAMILTON

HOW TO CONTROL ATMOSPHERES . . .

BAILEY COMBUSTIBLES ANALYZER



This generator produces atmosphere for the treatment of steel in a new, completely integrated eastern steel mill. A Bailey Combustibles Analyzer monitors and controls input fuel gas and controls performance. Other instruments on Bailey Panel are Bailey Fuel/Air Ratio Recorder and Selector Station.

compensates for variations in gas quality

Whether you are making your heat treating atmospheres out of natural gas or a by-product fuel, variations in gas quality are bound to occur. When this happens, it is impossible to maintain a satisfactory gas-air ratio without exact knowledge of how the atmosphere has changed. The Bailey Combustibles Analyzer provides the logical solution to the problem. In most applications it is sensitive to less than $\pm 0.2\%$ change in combustibles. It also assures uniform atmospheres and a uniform product.

In a commonly used Bailey control system, the Analyzer constantly samples the atmosphere gas. When per cent combustibles varies, a pneumatic signal from the recorder automatically controls the fuel rate to adjust the gas-air ratio and maintain the required amount of combustibles in the atmosphere.

A Bailey Oxygen Analyzer may be combined in the same case with the Combustibles Analyzer. Indicating and recording the per cent oxygen in heat treating atmospheres determines air leakage into the controlled atmosphere furnace. It may also be used as a further safety guide to indicate when a furnace has been purged effectively to permit the use of a hazardous blanketing gas.

Let a Bailey Engineer plan an analyzing and control system for you that will continuously safeguard the quality of your atmospheres and of your final product. Or, write to the Iron and Steel Division for Product Specification E65-3 with complete details on the Bailey Combustibles Analyzer. 59-1

BAILEY METER COMPANY

IRON AND STEEL DIV., 1047 IVANHOE ROAD, CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

INSTRUMENTS AND CONTROLS FOR POWER AND PROCESS

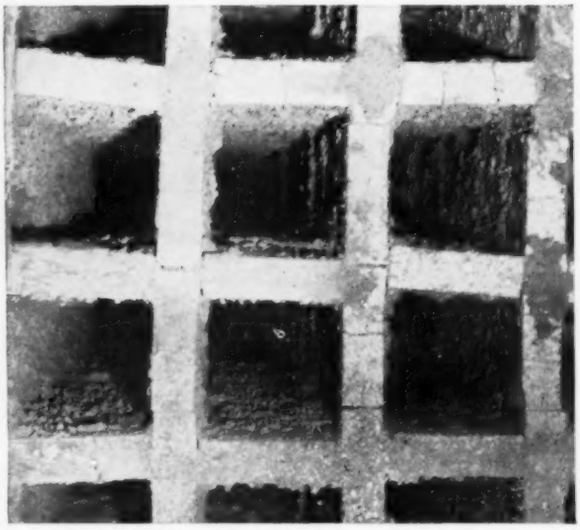
BAILEY BUILDING BLOCK METHOD

HARBISON-WALKER

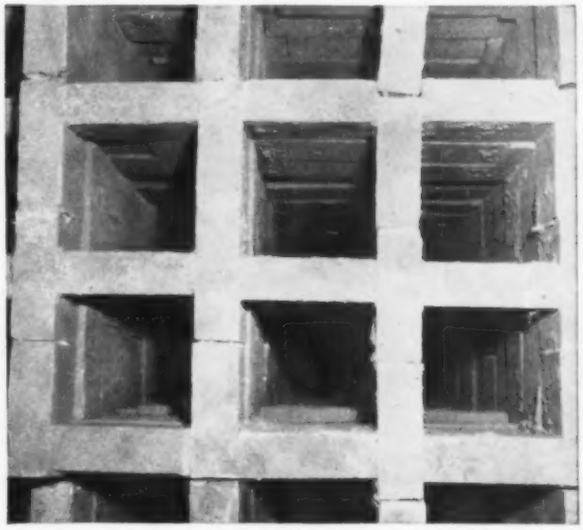
FORSTERITE L

BASIC CHECKERS

provide unusual advantages for open hearth steel furnaces



After two campaigns—378 heats—Forsterite L Open Hearth Checkers appeared as shown above. The friable character of the slight dust build-up is apparent.



Ready to go back into service. Cleaning is quickly and easily accomplished because Forsterite L Checkers resist slagging, spalling and clogging.

With the rapidly increasing use of basic brick checkers for open hearth steel furnaces, many of the various kinds have been in service for careful comparisons. Among the various classes of basic brick used in this application, FORSTERITE L, the magnesium-silicate refractory, shows unusual merit.

Important benefits which contribute to the good economy in the use of FORSTERITE L checkers are briefly enumerated.

1 Increased durability under the most severe operating conditions

FORSTERITE L checkers do not shrink or subside in soaking heats and higher preheat temperatures of the air are feasible. They are highly resistant to slagging and withstand the temperature changes involved without spalling. Because of the excellent stability of mineral composition under the prevailing regenerator conditions, FORSTERITE L brick do not permanently increase in volume nor become weak and friable.

2 Checker cleaning decreased

Due to its chemical composition, iron oxides and basic slag carry-over, do not readily react with FORSTERITE L. These basic fluxes do not wet the FORSTERITE L brick which remain clean and free from excessive clogging. The necessity of cleaning FORSTERITE L checkers used for all or part of the setting is greatly decreased.

3 Greater heat capacity

The inherent properties of the mineral forsterite account for the higher heat capacity of FORSTERITE L brand, than that of alumina-silica refractories. The heat capacity of a checker setting of a given size thus is greatly increased.

4 High efficiency maintained

FORSTERITE L checkers retain their normal texture and are less readily glazed than are various other kinds of basic, high alumina and alumina-silica refractories. High heat absorption is not reduced by increased reflection resulting from glazing.

HARBISON-WALKER REFRACTORIES COMPANY

AND SUBSIDIARIES

World's Most Complete Refractories Service

GENERAL OFFICES: PITTSBURGH 22, PENNSYLVANIA

IN INLAND STEEL'S ROLL DEPARTMENT

New Mack-Hemp electronic contouring lathe removes metal at peak rates with .001″ accuracy

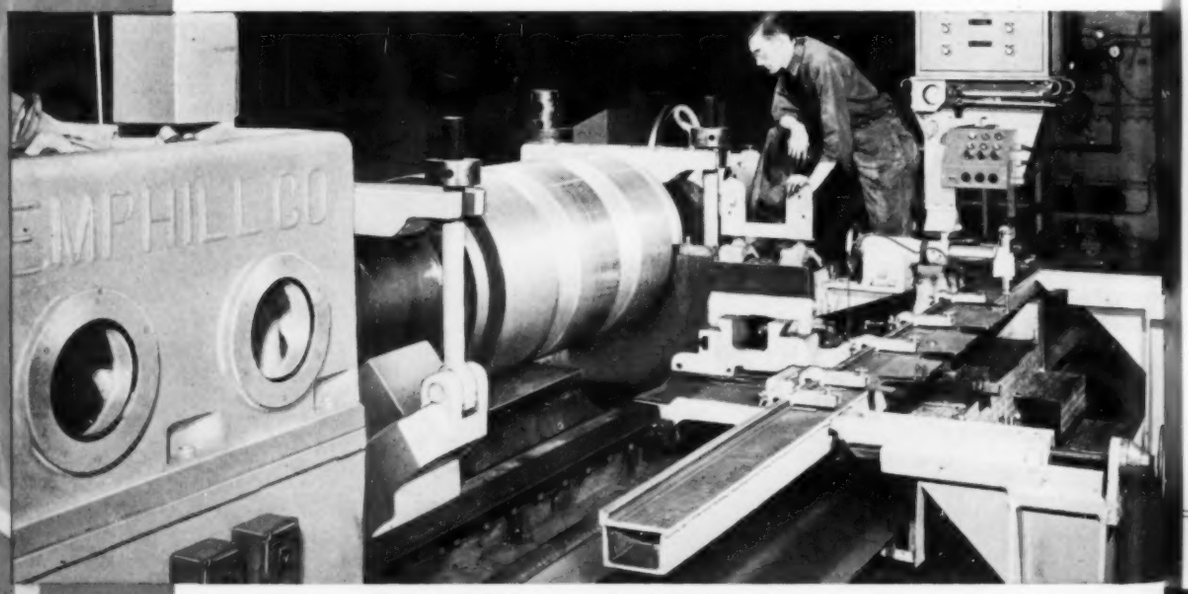
An electronic "pilot" guides this 48″ Mackintosh-Hemphill contouring lathe recently installed in the Roll Department at Inland Steel Company's Indiana Harbor Works. It is so precise that the lathe can finish contours into a roll without deviating more than .001″ from the pattern on the full-size template.

Stylus contact with the template controls the lathe's longitudinal- and cross-feed motors through electronic linkages. Thus, dual feed motion response of the tool holder carriage is instantaneous and smoothly continuous. Any conventional groove shape can be duplicated—it is even possible to make an accurate cut on a shoulder vertical to the axis of the roll.

But this precision of control is only one reason why the big lathe can turn shape rolls so rapidly. It has been designed and built to handle some of the heaviest torsional loads ever imposed on a lathe. For example:

> ***It can operate continuously through a ⅞″ cut depth with feeds between .060″ and .100″, and with spindle speeds up to 62 RPM. It can turn rolls or forgings 50″ in diameter and 18 feet long.***

If you are planning to install new large-roll turning capacity, you'll be wise to investigate these cost-cutting automatic contouring lathes. Write us today for complete information. They're available in 48″, 60″ and 72″ sizes.



Inland's new 48″ Mack-Hemp automatic lathe here is cutting passes into a new roll for a 3-high structural mill that rolls 15″ I-beams. Hardness of the roll is 42 Shore.

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Personnel News...

Leslie B. Worthington has been appointed president of Columbia-Geneva Steel Division of United States Steel Corp., with headquarters in San Francisco, Calif. In his new post, Mr. Worthington succeeds the late **Alden G. Roach.** For the last 11 years, Mr. Worthington has been president of U. S. Steel Supply Division, whose main offices are in Chicago. At the same time, **Loren J. Westhaver** was named executive vice-president. Mr. Worthington began his career with U. S. Steel in 1923 as a sales apprentice at the South Chicago Works of Carnegie-Illinois Steel Corp. He became assistant manager of sales in the Chicago District of Carnegie-Illinois in 1933 and, two years later, was appointed manager of the St. Paul district sales office. Subsequently, he was attached to the Detroit sales office for five years before being transferred to Pittsburgh, where he was in charge of sales of bar, strip and semi-finished materials for Carnegie-Illinois. In 1942, Mr. Worthington was elected vice president of U. S. Steel Supply Division, becoming its president in 1946.

Mr. Westhaver has been vice-president—operations for Columbia-Geneva since 1955. Formerly, he was the division's vice-president and manager of its Utah operations. He started with U. S. Steel in 1928 as a tester at American Steel & Wire Company's South Works in Worcester, Mass. He progressed through various positions to that of assistant superintendent and then superintendent of the open hearth and rolling mill departments. In 1939 he was made steel works superintendent. Transferred to the company's Donora, Pa., Steel & Wire Works in 1942, Mr. Westhaver was named general superintendent there in 1943. Appointed district manager of operations for the company at Duluth in 1949, he was transferred to a similar position with Geneva Steel Co. at Salt Lake City in 1950. **J. D. McCall** succeeds Mr. Westhaver as vice-president—operations. He has been general manager of operations for Columbia-Geneva since 1955. After starting his business career in Oakland, Calif., Mr. McCall joined Columbia Steel Co., in 1936 as an engineer and statistician at its Pittsburg Works. He later was promoted to assistant industrial engineer and in 1938, was named the plant's works industrial engineer. From 1940 to 1942, Mr. McCall served as assistant general superintendent at Columbia Steel's Torrance Works. Returning to Pittsburg Works as assistant general superintendent in 1942, he became general superintendent there in 1947. He was appointed assistant general manager—operations of the Columbia-Geneva Division in 1954.

Robert R. Elsasser has been named superintendent of Gambrinus plant tube mills, and **George Messer** superintendent of finishing departments of the Steel and Tube Division of The Timken Roller Bearing Co. Mr. Elsasser started with Timken as a sales trainee in 1936 and became sales engineer in the Cincinnati office in 1937. He returned to the Canton steel mill in 1942, as a processing engineer. He became superintendent of the Newton Falls plant in 1944. When that plant closed in 1946 he returned to Canton as assistant superintendent of finishing and was then promoted to assistant superintendent of tube mills, a position he held until his present promotion. Mr. Messer has been with the company since 1933 when he started as a machinist in the Canton Steel Mill. He was transferred to the Gambrinus die shop in 1940 as a machinist and supervised the training of new employes for that department. In 1945 he was promoted to general foreman of the Cold Draw Department, the job he held until his promotion to superintendent of finishing.

Robert Urquhart, who has been general superintendent of Lorain Works, National Tube Division, United States Steel Corp., has been transferred to the division's Pittsburgh office as an executive assistant to the vice-president—operations. A veteran of forty-three years in the steel industry, Mr. Urquhart joined U. S. Steel at the Homestead District Works. He served in various capacities there, eventually becoming assistant general superintendent of that works, until his appointment in February of 1948 as general superintendent of National Tube's Lorain Works. **Truman H. Kennedy** has been appointed general superintendent of Lorain succeeding Mr. Urquhart, and **Louis F. Sattele** has been named to succeed Mr. Kennedy as general superintendent of the Division's National Works, McKeesport, Pa. From 1933 until 1940 Mr. Kennedy held various positions with the Inland Steel Co. and the Interlake Iron Corp. in the blast furnace department. He joined National Tube in 1940 as assistant superintendent of blast furnaces at Na-

L. B. WORTHINGTON

L. J. WESTHAVER

ROBERT URQUHART

T. H. KENNEDY

L. F. SATTELE | H. N. HUBBARD | E. F. DONATIC | G. A. ZWISSLER

tional Works, McKeesport. The following year he was made superintendent of the furnaces and on January 1, 1946, he became assistant general superintendent there, being promoted to general superintendent in 1948, the position held at the time of his new appointment. Mr. Sattele, who before his new appointment was assistant general superintendent of Lorain Works, joined National Tube at Lorain in the operating department. In 1936, he was transferred to National Works as assistant superintendent of blast furnaces and in 1941 was named superintendent of pipe mills. One year later, he was transferred to the U. S. Steel Division's Ellwood Works, Ellwood City, Pa., as assistant general superintendent, and in 1943 was transferred again to Lorain as assistant general superintendent.

Howard N. Hubbard succeeds Mr. Sattele as assistant general superintendent of Lorain Works. Mr. Hubbard has been division superintendent of the lower works, operating dept., which includes all steelmaking facilities.

Ernest F. Donatic was named general superintendent at the Kaiser Steel Corp. plant at Fontana, Calif. Formerly assistant general superintendent of services, Mr. Donatic will assume responsibilities in coordinating the activities of the iron and steel, rolling mills, and services divisions at the plant. He joined Kaiser Steel in 1946 as assistant superintendent of maintenance, following 23 years with Republic Steel Corp. in Chicago, where he had been assistant superintendent in charge of electrical maintenance and crane repair.

Gordon A. Zwissler succeeds Mr. Donatic as assistant general superintendent in charge of services. From 1936 to 1946 Mr. Zwissler was employed in various plants of the Carnegie Illinois Steel Corp. and came to Kaiser from the Youngstown, Ohio, Works, where he had been superintendent of transportation and railroads. At Kaiser he was chief industrial engineer and then transferred to the blooming mill operations where he was appointed superintendent in 1948. In 1953 he became division superintendent, rolling mills, and directed the operations of the electric weld, continuous weld, cold roll, merchant-skelp, blooming and structural mills, the soaking pits, conditioning yards and cranes.

Reynold C. MacDonald was appointed division superintendent of rolling mills replacing Mr. Zwissler. He joined Kaiser in 1946 in the Industrial Engineering Department. He transferred to the rolling mills and worked as foreman and general foreman in conditioning

R. C. MAC DONALD

yards, then as assistant superintendent in the merchant-skelp mill, before assuming his post as superintendent in the blooming mill section in 1953.

H. H. McCorkle has been made superintendent of safety, Warren District, Republic Steel Corp., and **E. C. Norris, Jr.,** succeeds Mr. McCorkle as assistant superintendent of industrial relations.

Donald I. Bohn has retired from Aluminum Co. of America after more than 34 years of service. Mr. Bohn, whose retirement became effective January 1, had been Alcoa's manager of special electrical development engineering since 1953. Previously, he had served for nine years as the company's chief electrical engineer.

Chalmers C. McElvain has been named assistant manager at the Baltimore works of Armco Steel Corp. In addition **Walter H. Roskott** has been appointed works industrial engineer. Mr. McElvain was

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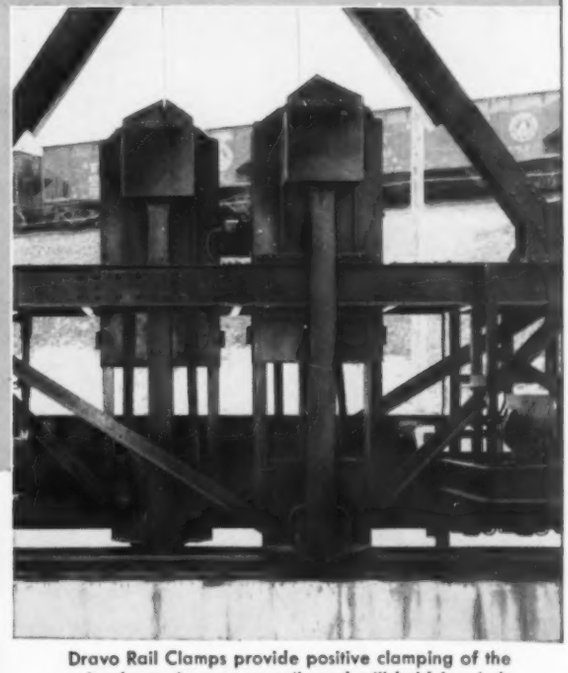

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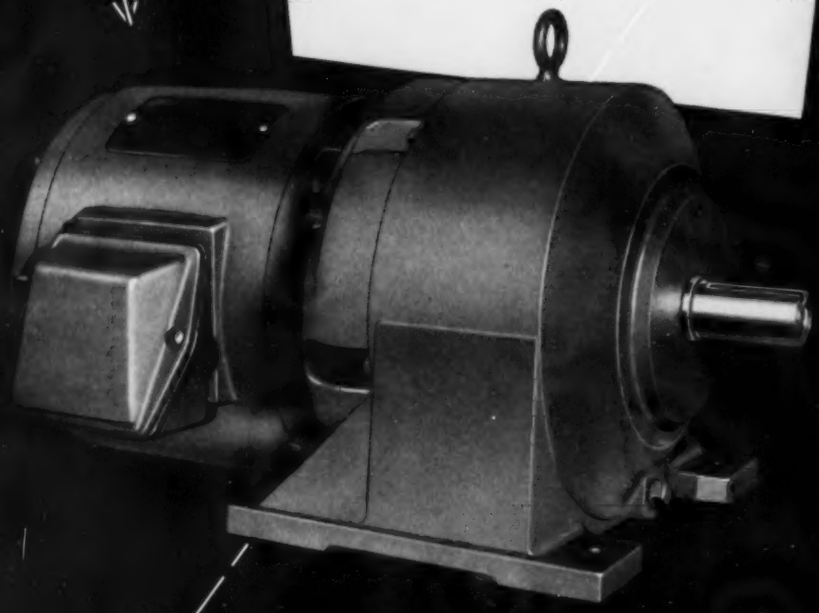
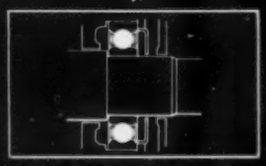
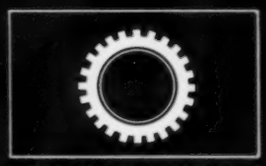
Don't overlook what you can't see



You can't always see what makes a gear-motor outstanding. It's the attention paid to small design details that makes the difference. Here are a few of the details that make the new Reliance Gearmotor stand above the rest.



FOOLPROOF METERMATIC motor bearing lubrication and oil bath gear lubrication for long-life protection against wear.



INDUCTION HARDENING of the tough alloy steel gears gives a perfect combination of wear resistance and strength.

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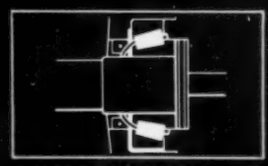

THRUST BEARINGS handle heavy overhung loads safely by placing strain on the frame instead of the shafts.

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E-1509

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formerly administrative assistant to the manager and head of the industrial engineering department. After several assignments at Armco's general offices at Middletown, Ohio, he came to the Baltimore Works as works industrial engineer in 1945. Mr. Roskott has been with Armco since 1940, and was formerly senior industrial engineer at the Baltimore Works.

Reinhold Schempp has been named manager of Crucible Steel Co. of America's Sanderson-Halcomb Works, Syracuse, N. Y., and **S. A. Fronek** was chosen to head Park Works in Pittsburgh, Pa. Each previously served as assistant manager of his respective plant. Mr. Schempp succeeds **R. A. Schneid** and Mr. Fronek replaces **S. A. Jackson.** Both Mr. Schneid and Mr. Jackson retired on December 31, 1956.

F. Bruce Bevelheimer has joined Jones & Laughlin Steel Corp. as power and fuel engineer on the staff of the chief engineer. Mr. Bevelheimer comes to J & L from the Steel Division of the Ford Motor Co., where he served in a similar position. Prior to joining Ford, he spent two years at Colorado Fuel and Iron Corp., and 19 years in the fuel department of Bethlehem Steel Co.'s Sparrows Point Plant.

S. W. Wheeler has been named assistant chief engineer of Republic Steel Corp.'s Warren Ohio, District. Mr. Wheeler, mechanical engineer for the district since 1948, succeeds **I. H. Lundgren** who recently was promoted to chief engineer.

Owen R. Rice and **Fred W. Rys** have been given new assignments in the Engineering and Construction Division of Koppers Company, Inc. Mr. Rice, a divisional vice-president who formerly was manager of the Freyn Engineering Department, has been named a special consultant to **Dr. Rueckel.** Mr. Rys has been named to succeed Mr. Rice as vice-president and manager of the Freyn Department.

Conrad F. Nagel, Jr., vice-president of Aluminum Co. of America has retired after more than 41 years' service with Alcoa. Mr. Nagel became chief metallurgist for Alcoa in 1944, and was elected a vice president in 1952. He also has served as chairman of Alcoa's technical committee.

Donald H. Turner, a specialist in the melting of refractory metals, has been appointed supervisor of melting and heat treating services at Armour Research Foundation of Illinois Institute of Technology. He will be in charge of precision heat treating of metals, including special materials, and vacuum induction and arc melting processes.

Dr. Clarence Zener has been appointed director of the Westinghouse Research Laboratories. Dr. Zener assumes his new post after five years as an associate director and a year as acting director of the Laboratories.

William C. Ruland, district sales manager for Yale & Towne Manufacturing Co., hoisting equipment in the St. Louis, Mo., area, has been promoted to a similar position in the Detroit, Mich., area. He succeeds **Neal Kemp** who was recently appointed a regional sales manager for all Yale materials handling equipment in the Midwest.

Paul M. Brister has been appointed manager of the Engineering Design Section of The Babcock & Wilcox Co.'s Manufacturing Engineering Department. Succeeding Mr. Brister in the New York office as Engineering Department coordinator is **William D. Stevens.**

F. L. Griffith and **F. W. Blanchard** were elected vice-presidents of Hewitt-Robins, Inc. Mr. Blanchard will be responsible for manufacturing and engineering in the company's industrial products divisions. During the last six months he has been serving as assistant to the executive vice president, and previous to that was manager of operations of the Hewitt Rubber Division's plant at Buffalo, N. Y. Mr. Blanchard joined Hewitt-Robins in 1936 as an engineer and draftsman. He subsequently became plant engineer, chief engineer and, in 1945, factory manager.

Kenneth L. Vore has been appointed an assistant vice-president—traffic of the United States Steel Corp. Mr. Vore has been general traffic manager of the Westinghouse Electric Corp. since 1953.

A. I. Nussbaum, formerly sales manager of Stanat Manufacturing Co. Inc., has joined the Loma Machine Manufacturing Co. Inc. and will be in charge of their Rolling Mill Division. Mr. Nussbaum has had twelve years of experience in the fabrication of ferrous and non-ferrous semi-finished products.

Fred M. Gillies was elected chairman and chief executive officer, and **Guy T. Avery** was elected president and chief administration officer of Acme Steel Co. **Carl J. Sharp,** former chairman, continues as chairman

REINHOLD SCHEMPP

S. A. FRONEK

F. B. BEVELHEIMER

S. W. WHEELER

G. T. AVERY | J. P. WILLIAMS | J. O. DAGUE | T. W. WILSON

of the executive committee. Mr. Avery, the new president, has been with Acme Steel 36 years, and has been executive vice-president since 1953.

James P. Williams was appointed manager of engineering and planning at the Kaiser Steel Corp. plant, Fontana, Calif. Mr. Williams came to Kaiser as chief industrial engineer in 1945 from Geneva Steel, Utah, where he had been plant industrial engineer. Previously he had served as assistant to the chairman of the open hearth, bessemer and rolling mills committee at the Pittsburgh office of United States Steel.

James O. Dague was appointed superintendent of the mechanical department at Bethlehem Steel Co.'s Lackawanna, N. Y., plant. Mr. Dague, assistant superintendent since 1949, succeeds the late **W. C. Daniels.**

Thomas W. Wilson, safety supervisor of the Buffalo plant of Republic Steel Corp., has been promoted to the newly created position of assistant superintendent of industrial relations for safety, fire prevention, and housekeeping. He started with Republic as a strander in the eight-inch bar mill in 1937. Subsequently, he advanced to the combustion engineering department and in 1946 was named assistant safety supervisor. In March 1952, he was promoted to safety supervisor.

John E. Kearns has been appointed manager of a new Bristol Co. district sales office at San Francisco, Calif. Mr. Kearns has been with Bristol since 1936. He has served as sales and service engineer at the company's New York, Birmingham, and New Orleans offices. For the past four years he has been in the Application Engineering Department at the home office, specializing in automatic control.

Thomas M. Rees, formerly President of the Rees Machinery Co., Inc., of Pittsburgh, Pa., is now affiliated with the Stanley Berg Machinery Co. in the sale of heavy machinery in the Pittsburgh and tri-state area.

R. W. Vollmer has been named to fill the newly created position of assistant to the general manager of the Engineering and Construction Division of Koppers Co., Inc. At the same time **J. S. Atwood** was appointed to succeed Mr. Vollmer as manager of the Chemical Department of the Engineering and Construction Division.

Quentin M. Bloom was promoted to manager, Furnace and Kiln Division and **Charles A. McFadden** to manager, General Industry Division of Selas Corp. of America. Mr. Bloom joined Selas in 1940 as design engineer and subsequently served as sales engineer and

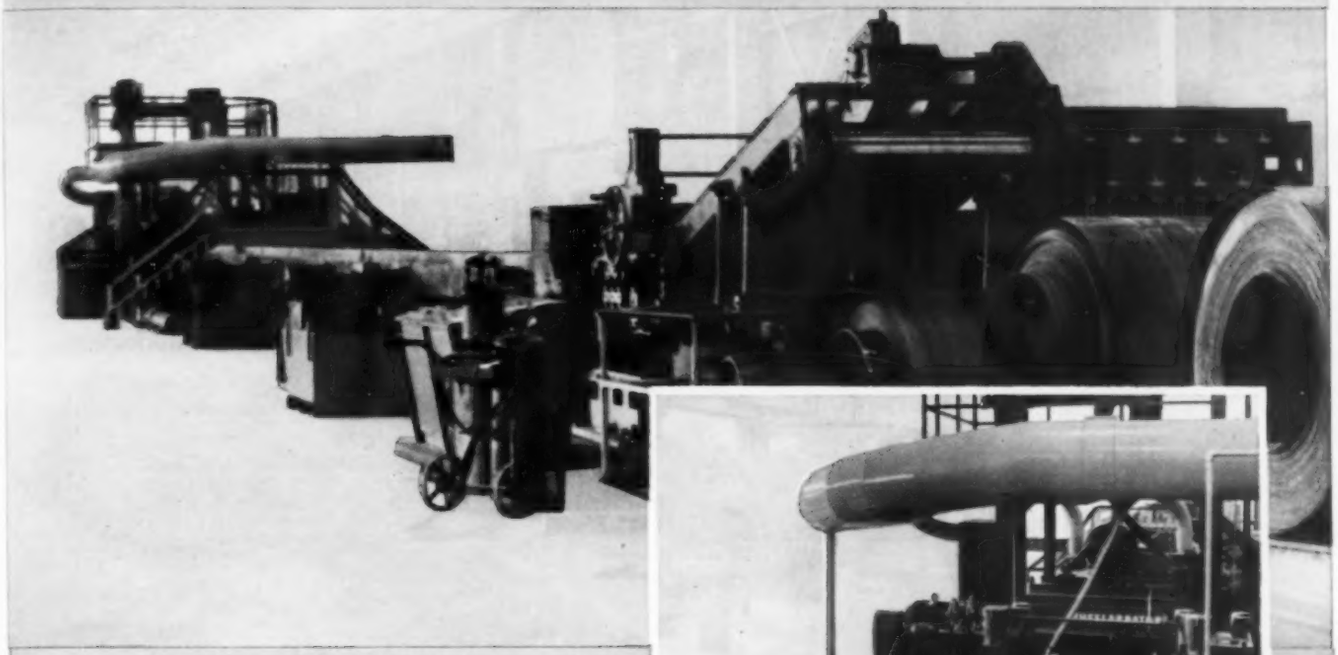
Q. M. BLOOM

as project engineer. Mr. McFadden has been with Selas since 1943, joining the firm as fuel engineer in the laboratory, and later became sales engineer and project engineer.

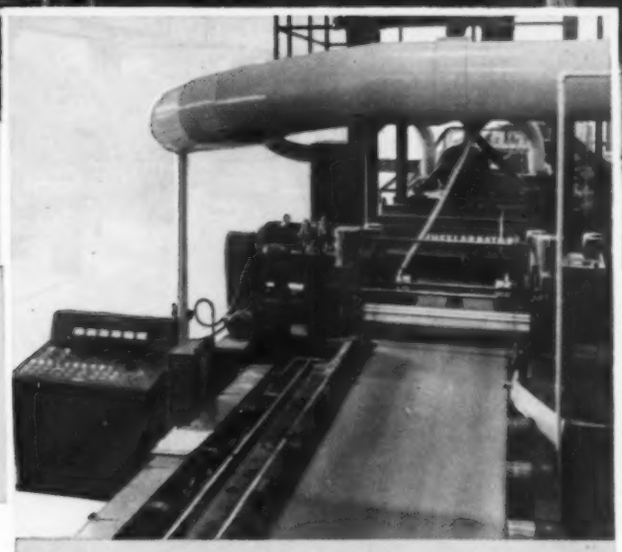
Raymond C. Withrow has been appointed to the position of manager of rust preventive sales, Valvoline Oil Co. Mr. Withrow, who was manager of industrial lubrication oil and grease sales, will be succeeded by **Taylor A. Hied,** previously technical service engineer.

David H. Nicholson was named vice-president of manufacturing of Morgan Engineering Co. Mr. Nicholson came to Morgan after two years with the Electric Storage Battery Co. where he was director of personnel and industrial relations for Philadelphia operations.

Stamco * heavy gauge feeding equipment and trimmers



CONE PAYOFF STRIPPER, FLATTENER AND SHEAR



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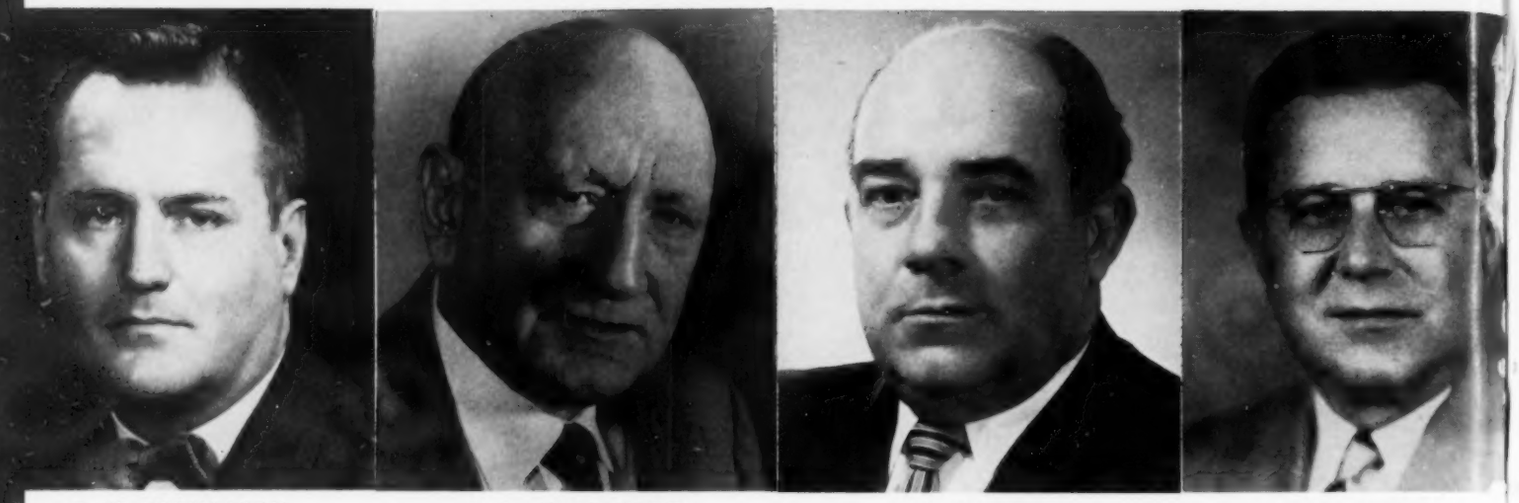

D. H. NICHOLSON | A. L. HOLLINGER | D. K. MARTIN | V. F. STINE

From 1946 to 1951, he was assistant director, industrial relations at U. S. Pipe and Foundry Co. He was also director of personnel for the Fort Pitt Steel Casting Co. for seven years.

Albert L. Hollinger, vice-president, Surface Combustion Corp., has been appointed vice-president in charge of sales of all industrial divisions of the corporation. Mr. Hollinger has been sales manager of the Steel Mill Division since 1930. **Donald K. Martin,** Pittsburgh District sales manager, is the newly appointed sales manager of the Steel Mill Division. Mr. Martin has been with the corporation for 27 years. During the major portion of his career he has been associated with field construction and operation of large steel mill installations. In 1943 he was transferred to the Pittsburgh office, where he later headed up sales of both steel mill and heat treat furnaces.

Victor F. Stine has been elected to serve as the new president of Pangborn Corp. at the same time **Ralph M. Trent** was named a director and executive vice-president, and **W. O. Vedder** a vice-president. **Thomas W. Pangborn,** founder and president of the corporation since 1904 will continue to serve as chairman of the board of directors, while **John C. Pangborn,** former 1st vice-president will fill the office of vice-chairman of the board.

Obituaries

J. Heber Parker, 75, chairman of the board of directors of the Carpenter Steel Co., died Dec. 28.

George R. Flierl, superintendent, power and fuel department at Sharon Steel Corp., died November 22, 1956.

Terryl B. Montgomery, 56, chief engineer of Allis-Chalmers Manufacturing Co.'s electrical application department, died Dec. 7.

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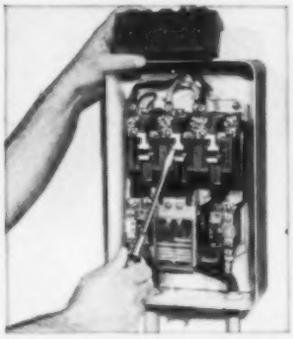
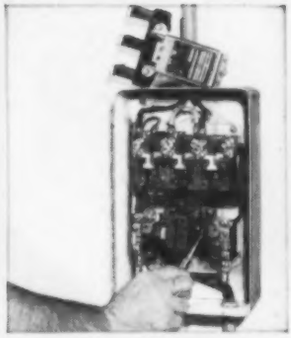
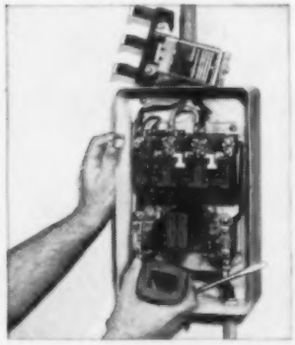


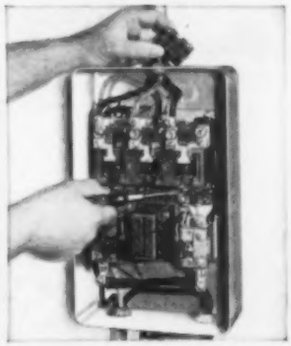
1 Loosen two screws and the arc chamber cover comes off. Every contact surface can be inspected at a glance.



2 Remove four screws and entire movable assembly can be lifted off. Disconnect two wires and slip off magnet coil.



3 Contacts are attached with separate screws—they can be removed and replaced without disturbing any wiring. A screwdriver is the only tool needed.



4 Sizes 0 through 4 starters have these separate mounting electrical interlocks for easier installation. Contact block is attached from front of panel with two screws.

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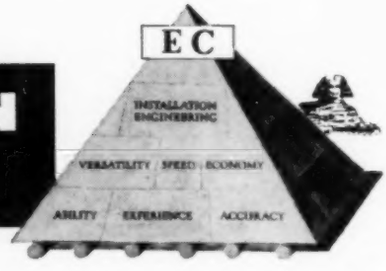

Publication Service...

FEBRUARY, 1957

(1) Insulating Firebrick

A bulletin that gives a detailed description of the relationship between heat losses and the weight of refractory linings has been published by The Babcock & Wilcox Co. The results of the studies performed on a number of producing installations are included as evidence of the fuel savings made possible by the use of light weight insulating firebrick. (R-43)

(2) Engineering Projects

Kaiser Engineers has published a booklet explaining their performance in major industrial projects. The booklet discusses how the firm makes a careful advance study of all the related problems involved in a project, thereby insuring the execution of a better planned project. It also relates Kaiser's experience in all phases of engineering analysis and design.

(3) Cast Alloys

The latest revision of the list of standard designations and chemical composition ranges for heat and corrosion resistant cast alloys has just been issued by the Alloy Casting Institute. Noteworthy is the addition of two new cast alloys of the "18–8" variety, with very low carbon contents.

(4) Insulated Cables

National Electric Products Corp., has released a bulletin discussing the composition, tested "in use" properties and suggested applications of insulated-neoprene sheathed non-metallic cables. The bulletin contains evidence of the "weathering" properties of their rubber insulated-neoprene sheathed, non-metallic cables when exposed to aggressive sun, water and soil conditions. Appropriate charts provide data on size, strand construction, insulation sheathing, outer diameter and shipping weights.

(5) Industrial Lighting

A new industrial lighting booklet has been made available by Sylvania Electric Products, Inc. The booklet features sections on safety and visibility factors, standards for use in prescribing plant lighting, uses of fluorescent, incandescent and mercury vapor lamps; lighting of other areas, maintenance, and condensed catalog data on fixtures. The booklet outlines the four related visibility factors of size, contrast, time and brightness, and lists 10 advantages to be gained from improved lighting. Following a section which details the standards and measurements used in prescribing proper lighting for plants, the booklet features special sections on the three major light sources commonly used for industrial illumination—fluorescent, mercury vapor and incandescent. Another section discusses fixtures for each of the three light sources.

(6) Silicone Lubricants

A new comprehensive brochure describing all silicone lubricants available in quantity from Dow Corning Corp. has been released. Properties and performance of various silicone oils, greases and compounds are discussed. Many typical applications are listed and illustrated, and the booklet includes helpful technical data in easy to understand tables and graphs. Special attention is given to high speed, high temperature ball bearing problems, and the relative influence of such considerations as bearing load, speed, metal combinations and fit-up are explained in detail.

You Can Obtain . . .

. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

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51	BAILEY METER CO.	SPEC. E65-3	Combustibles analyzer
52	BRISTOL CO.	BULLETIN P1260	Automatic heating controls
53	BROOKS OIL CO.	BULLETIN K-26	Lubrication
54	BUSSMANN MFG. CO.	BULLETINS HCS & FIS	Dual-element fuses and hi-cap fuses
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62	ELLIOTT CO.		Motors
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67	GEAR GRINDING MACHINE CO.		Constant velocity universal joints
68	HARNISCHFEGER CORP.		Evaluation of crane bids
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70	JOHNS-MANVILLE CORP.	IN-115A	Insulating firebrick
71	JOY MANUFACTURING CO.	BULLETIN B-41	Electrical connectors
72	KAISER ALUMINUM & CHEMICAL CORP.		Refractories
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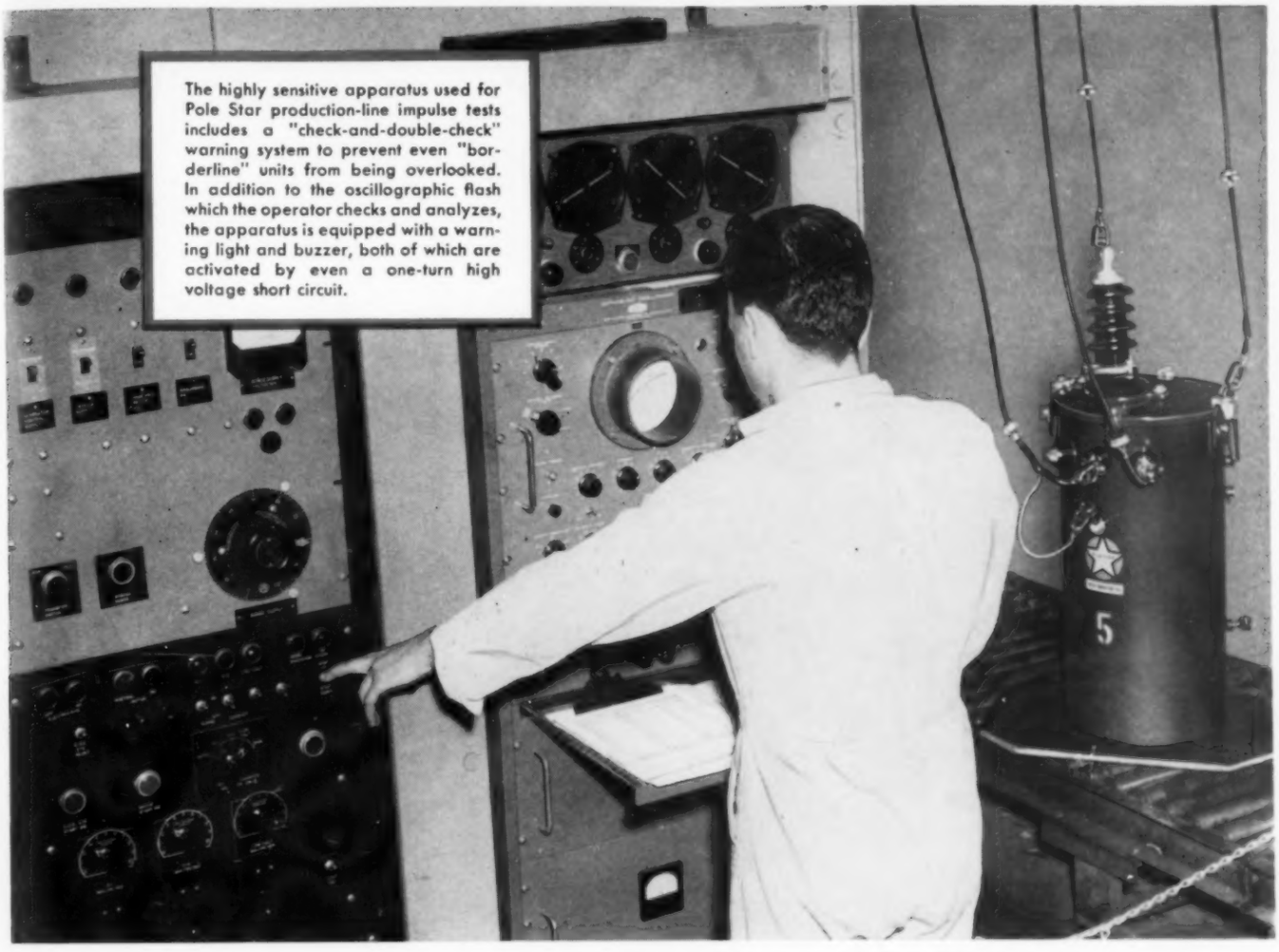

The highly sensitive apparatus used for Pole Star production-line impulse tests includes a "check-and-double-check" warning system to prevent even "borderline" units from being overlooked. In addition to the oscillographic flash which the operator checks and analyzes, the apparatus is equipped with a warning light and buzzer, both of which are activated by even a one-turn high voltage short circuit.

He's checking the POLE STAR's impulse before giving it a clean bill of health

After Pole Star distribution transformers have passed all required ASA and NEMA tests*, they are given a series of final checks to make absolutely certain they are just as dependable as their name implies. Every Pole Star from 3 through 100 kva, 18 kv and below is *completely impulse tested without arresters* — being subjected to production-line tests that simulate the impulse surge conditions likely to occur throughout the entire transformer during actual service.

Such thorough testing of each Pole Star's resistance to impulse surges is accomplished by checking the effect of surges between layers and turns as well as to ground.

The apparatus used for detecting failures during these tests is so sensitive that it will disclose *even* a one-turn high voltage short circuit.

This rigid quality control — typical of Pennsylvania's production methods — means added years of trouble-free service with Pole Stars, and important reductions in maintenance.

**ASA and NEMA standards require tests for winding resistance, winding and tap ratio, polarity and phase relation, core loss, exciting current, copper loss, and impedance, as well as applied and induced voltage insulation tests. These represent only a partial listing, however, of the numerous tests — both mechanical and electrical — which Pole Stars and their component parts and materials must undergo.*

167 Production Controls make Pole Star Best!

PENNSYLVANIA TRANSFORMER COMPANY

A McGraw Electric Company Division **CANONSBURG, PA.** *Greater Pittsburgh District*

Pole Star Transformers are available in all standard single phase distribution sizes from 3 through 500 kva, through 67,000 volts.

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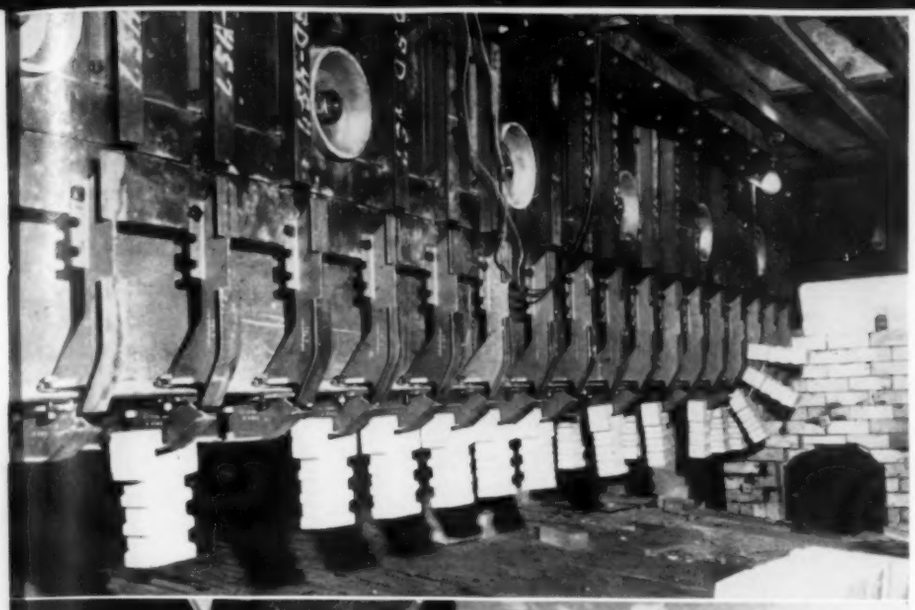

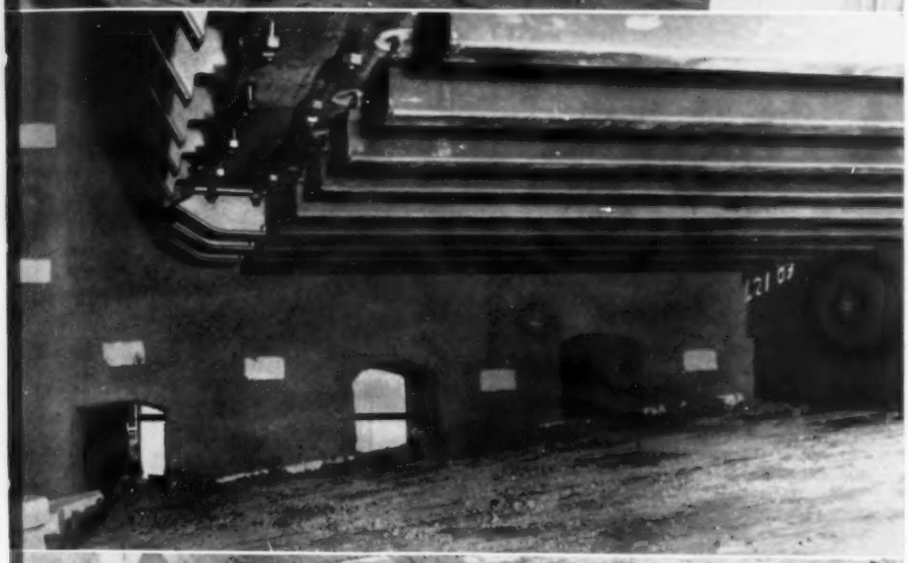

ANOTHER COMPLETE RAMTITE® NEW FURNACE ENCLOSURE

of a reheat ball mill furnace at Algoma Steel Corp., Ltd. Sault Ste. Marie, Ontario, Canada

Furnace is 38′-0″ wide inside.

Furnace side walls consist of block insulation against the steel casing, then a lining of insulating firebrick and 12″ of Ramtite securely anchored to the outside casing by corrugated anchor tile.

Roof, burner wall and nose of Ramtite, 9″ thick and suspended by the same type anchor tile, to steel supporting members.

Previous experience with Ramtite in a roof over a structural and rail mill furnace about 20′ by 35′, soaking pit covers, and burner walls in their double and triple fired reheat furnaces was proof enough to warrant the use of Ramtite for a complete lining in this furnace.

For further information about Ramtite products and services, contact your local Ramtite representative or mail the coupon below.

The Ramtite Co.
DIV. OF THE S. OBERMAYER CO.

THE RAMTITE CO., Div. of The S. Obermayer Co.
1813 South Rockwell St., Chicago 9, Ill.

Please send items checked

- ☐ Bulletin on Castable and Gunning Refractories
- ☐ Steel Plant Bulletin

Company Name _____

Attn. Mr. _____ Title _____

Address _____

City _____ Zone _____ State _____

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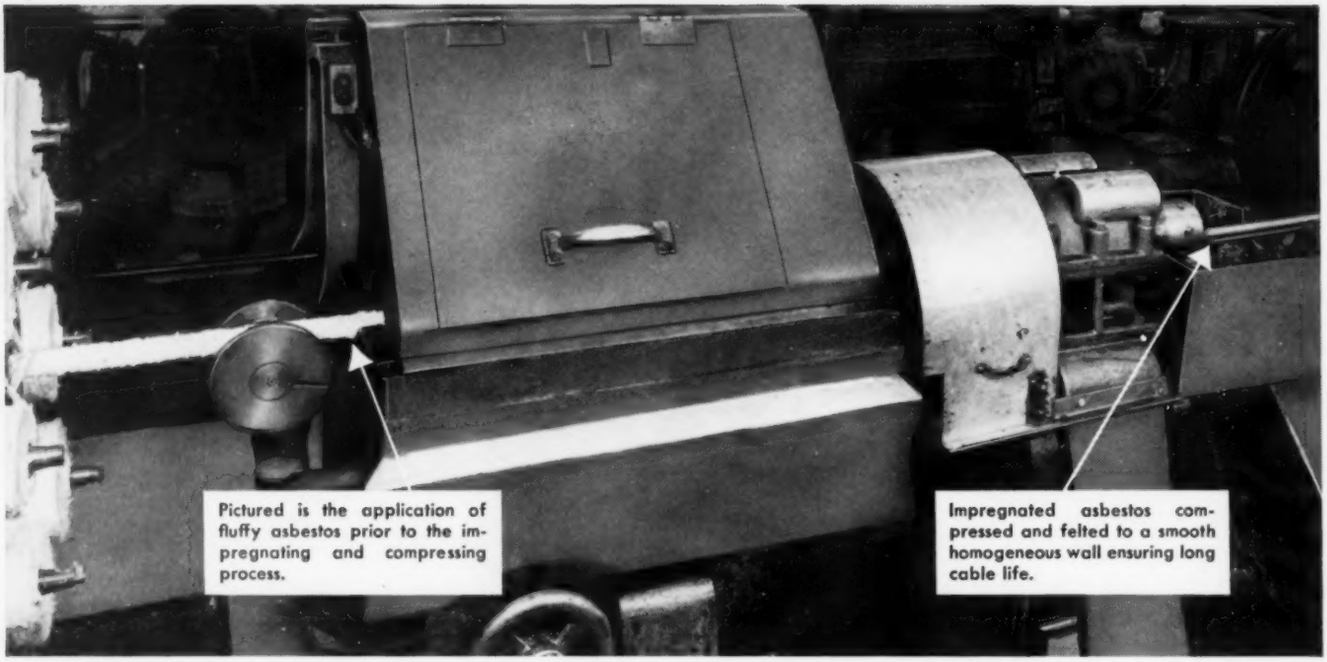
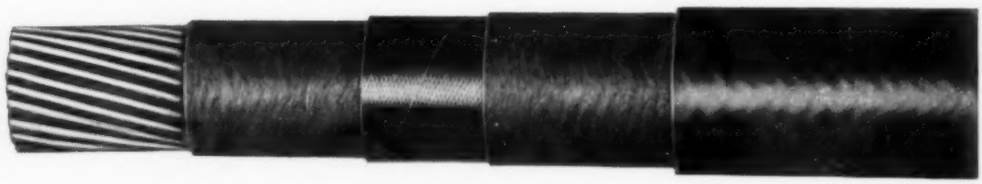
This is another in a series of advertisements depicting ways Ramtite Refractories serve the steel industry.


Pictured is the application of fluffy asbestos prior to the impregnating and compressing process.
Impregnated asbestos compressed and felted to a smooth homogeneous wall ensuring long cable life.

Felted Asbestos Walls + Impregnation with Selected Compounds + Quality Varnished Cambric Tapes . . .



That's the Backbone of

ROCKBESTOS A.V.C.® (N.E.C. TYPE AVA) QUALITY

Different brands of N.E.C. Type AVA wire and cable may look alike on the surface but the sure proof of quality that means dependable service is beneath the braid.

In the Rockbestos A.V.C. construction dense, felted, thoroughly impregnated asbestos walls seal the varnished cambric tapes away from air and moisture.

The varnished cambric tapes are made to Rockbestos exacting specifications and are applied under controlled methods assuring uniform dielectric strength.

The result . . . you get long life and dependable service under every type of operating conditions . . . in temperatures up to 230°F.

Complete construction and test specifications of Rockbestos A.V.C. are in the new booklet: "Specifications RSS-88". Write for your copy.

ROCKBESTOS PRODUCTS CORPORATION
NEW HAVEN 4, CONNECTICUT
NEW YORK • CLEVELAND • DETROIT • CHICAGO • PITTSBURGH • ST. LOUIS
LOS ANGELES • NEW ORLEANS • OAKLAND, CALIFORNIA • SEATTLE

STOCKED COAST TO COAST
Standard Rockbestos A.V.C. construction (N.E.C. types AVA, AVB, etc.) are available for immediate shipment. Call or write nearest branch office.

TRANTINYL GUIDES THE STEEL INDUSTRY

U. S. Steel Gary Works rolled 100,000 TONS with this pair of "TRANTINYL" GUIDES

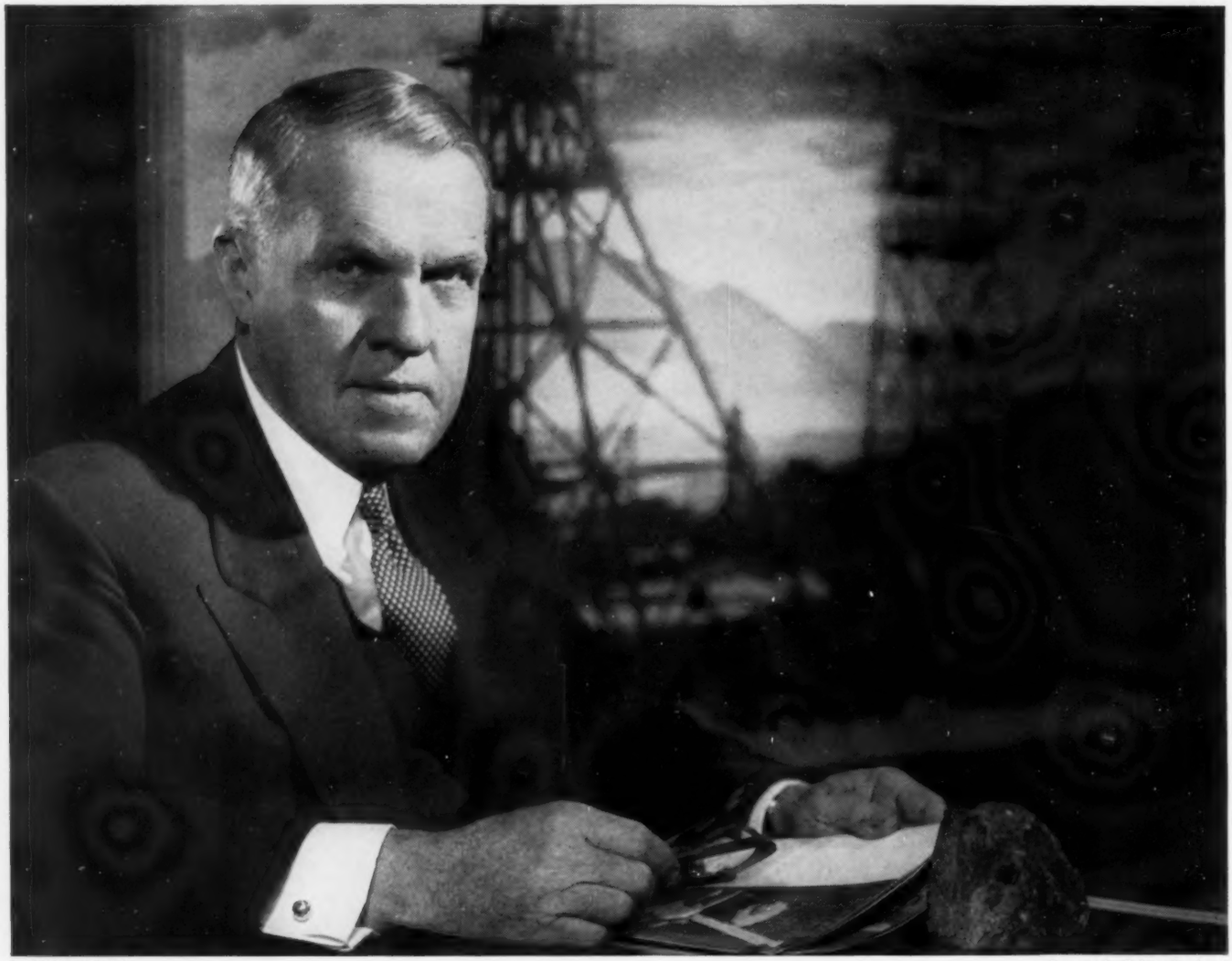
These entry guides on finishing stand, 14" mill, were photographed after rolling 100,000 tons of rounds. Guides were still in serviceable condition.

14" Mill, Gary Works, with "TRANTINYL" Guides and Guide Box

"Trantinyl" Guides and Rollers hold exceptionally high tonnage performance records, in serving leading steel mills for a quarter-century.

Youngstown Alloy Casting Corporation
Youngstown, Ohio

Sole Licensee to cast "TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.



CLYDE E. WEED

Portrait by Fabian Bachrach

"22,514 Anaconda Employees Are Buying U. S. Savings Bonds

"In October, 1955, only 34% (11,140) of the nearly 33,000 Anaconda organization employees in this country were buying U. S. Savings Bonds through the Payroll Savings Plan.

"Late in 1955, we conducted a simple person-to-person canvass which put a Payroll Savings Application Blank in the hands of every employee. There was no pressure, no special promotion – just the Application Blank. Our employees did the rest.

"Recently, our records showed that 22,514 of our men and women–69%–are now Payroll Savers. Every new employee is given a Payroll Savings Application Blank and an opportunity to join with his fellow workers in building personal security through systematic thrift.

"We believe The Payroll Savings Plan–with an enrollment of 8,000,000 employees of more than 40,000 companies–is a significant contribution to the Government's effort to check inflation and maintain a sound dollar."

CLYDE E. WEED, *President*
The Anaconda Company

Why not take a *personal* interest in *your* Payroll Savings Plan? Your State Director will be glad to show you how to install the Payroll Savings Plan or revitalize an existing plan. Phone, wire or write, today, to Savings Bond Division, U. S. Treasury Department, Washington, D. C.

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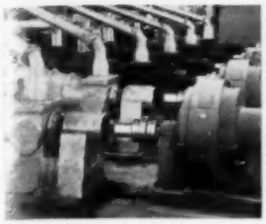
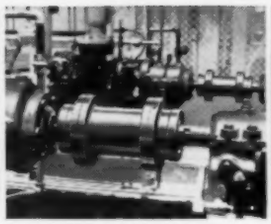
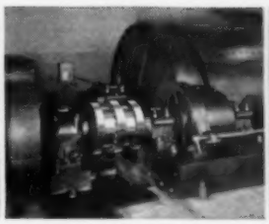
IRON and STEEL ENGINEER



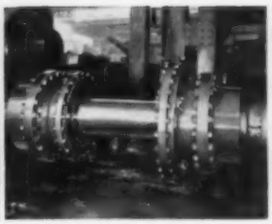
Paper Industry



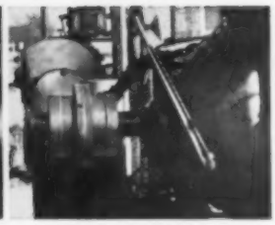
Oil and Gas Industry



Marine Industry

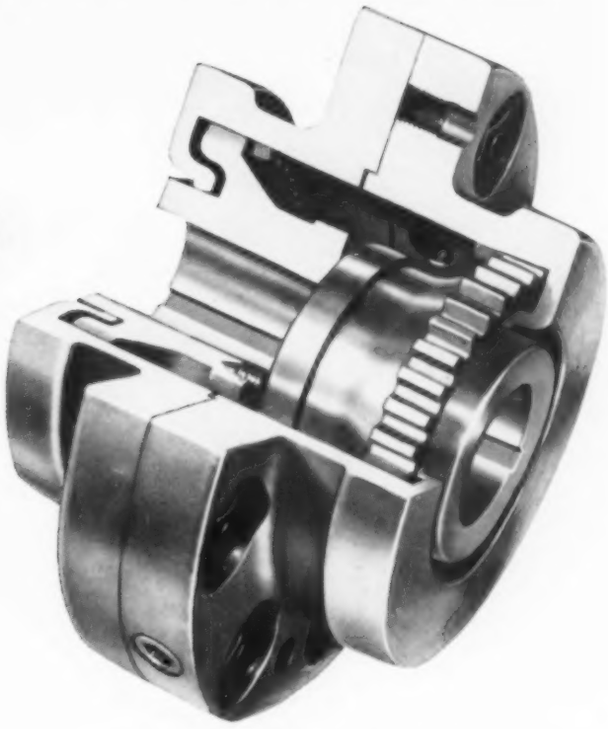


Steel Industry

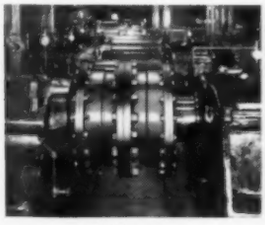


Oil and Gas Industry

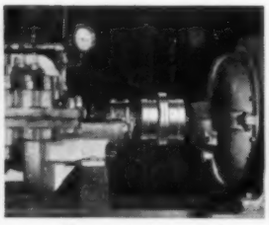
Why have Fast's Couplings always been the leader in the rugged steel industry?



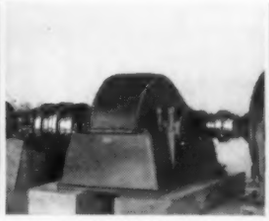
Why are they used so widely to couple machinery in Power Generation, Pulp and Paper, Oil and Gas, Marine Propulsion and Auxiliaries, Steel and industry in general?



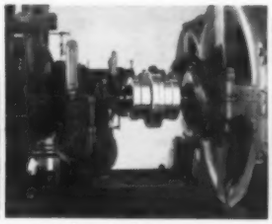
Steel Industry



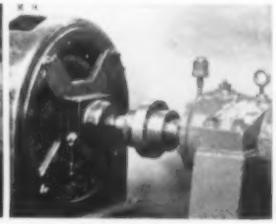
Power Industry



Lumber Industry



Chemical Industry



Paper Industry

Fast's Couplings are standard equipment with more machinery manufacturers than any shaft coupling on the American market. Many Fast's Couplings in use over 30 years still show no signs of wear when disassembled! That's the answer: they're reliable, they're *mechanically* flexible, they don't wear. They have no parts subject to repeated bending, tension or compression. There is no metal-to-metal contact, because of *positive lubrication.* Regardless of your field—no matter whether your connected machine is driven by steam turbine or electric motor, low-speed diesel or high-speed gas turbine . . . Koppers has the perfect, low-cost solution to your shaft coupling problem.

For free catalog write to: KOPPERS COMPANY, INC., *Fast's Coupling Dept., 3002* Scott St., Baltimore 3, Md.

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Aeromaster Fans, Industrial Gas Cleaning Apparatus, Gas Apparatus.

Engineered* Products Sold with *Service

KOPPERS

THE ORIGINAL

FAST'S Couplings

Trabon
LUBRICATION SYSTEM
keeps veteran mill rolling

Before starting up in the fall of 1936, this rolling mill was equipped with a Trabon Centralized Lubrication System, shown in red.

Each bearing has received measured amounts of grease at the correct time, day in and day out, for these twenty years. Because lubrication has been automatically performed by a Centralized Trabon System, bearing failure has been virtually non-existent.

How is your equipment lubricated? Only a Trabon System can bring you all these advantages:

1. **Save dollars. The number of man hours saved in a few months will pay for a Trabon System.**
2. **Reduce down time. A Trabon System lubricates while the machine is running with no hazard to the operator.**
3. **Positive check on lubrication. A Trabon System automatically indicates any stoppage of lubrication and provides a simple method of tracing the trouble.**
4. **Extend machine life. A Trabon System lubricates every point correctly, eliminating burned out bearings due to improper lubrication.**

In the Trabon line of oil and grease systems you will find a system that exactly suits your equipment. May we send you some literature on the subject?

Trabon "Centralized" OIL AND GREASE SYSTEMS

"Meterflo" CIRCULATING OIL SYSTEMS

Trabon ENGINEERING CORPORATION

28815 AURORA ROAD • SOLON, OHIO

Oil and Grease Systems

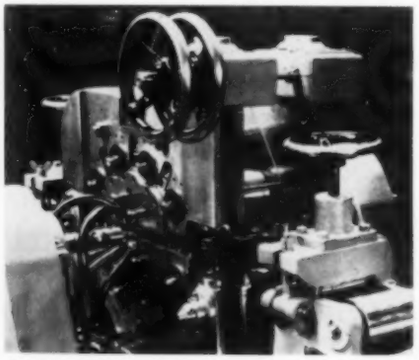
Equipment News...

CLUSTER MILL

▲ Development of a reversing cluster mill capable of rolling strip from about 0.010 in. to 0.0001 in. finishing thickness has been announced by Loma Machine Manufacturing Co., Inc.

Already proven in the industrial processing of such highly work-hardening metals as 18-8 stainless steel, high-temperature super-alloys, silicon steel, molybdenum, beryllium copper, platinum alloys, nickel-iron alloys and similar magnetic materials, the machine is filling the current need for a narrow-width cluster rolling mill for the production of ultra-thin strip.

The machine is available in a number of sizes, employing such work rolls as $\frac{7}{16}$ in. x 4 in., $\frac{1}{4}$ in. x 4 in. and $\frac{5}{32}$ in. x 3 in. Furthermore, the mill drive can be applied either to the work rolls, the intermediate rolls or the backup rolls. The mill is also available in a twelve-high design, and a six-stand tandem arrangement of this type with $1\frac{1}{4}$ in. x 7 in. work rolls is being used in the

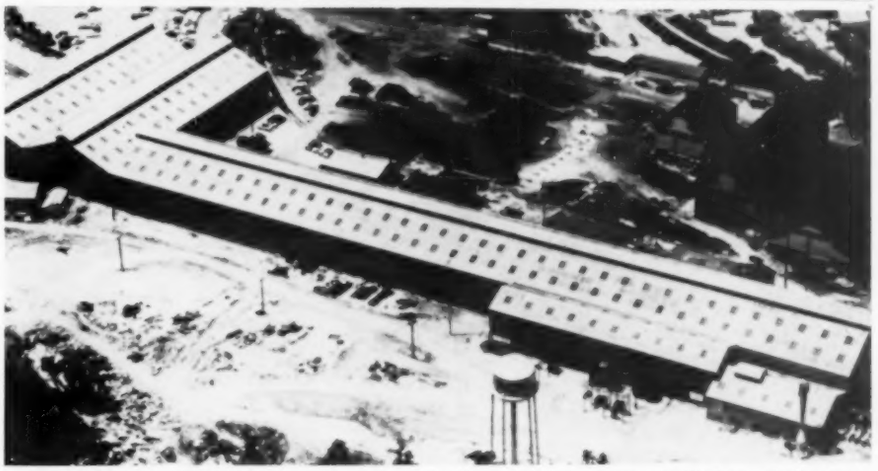


cold reduction of carbon steel strip to 0.004 in. The machine is normally powered by a variable voltage d-c drive, arranged for constant tension winding. Generally, a variable speed range up to 100 fpm and a coil build-up range from 6 in. I.D. to 12 in. O.D. is provided. By using a dual set of coilers, a tension range as high as 1000:1 is obtainable.

Compared to a conventional four-high unit, this new Rohn-type mill can finish-roll strip to considerably thinner gages, taking much heavier reductions per pass and greater total reductions between anneals. Moreover, the cluster mill can hold the closest obtainable thickness tolerances and produces strip of excellent flatness, even at 0.0001 in. finishing thickness. Such ultra-thin gage cannot be obtained on ordinary mills with relatively large work rolls because the very high ratio of contact length to strip thickness causes an extremely high resistance to deformation. The cluster arrangement has the additional advantage of preventing the bowing out of the slender work rolls in the direction of forward tension, which makes it difficult in the four-high mill to maintain the correct strip shape.

Outstanding feature incorporated in the new design is the use of proper backup rolls with heavy-duty antifriction roll neck bearings instead of idler backup bearings mounted on non-rotating shafts. This improvement permits 60 per cent higher rolling pressures and facilitates the greatest possible concentricity and, hence, closest strip thickness tolerances. The high-precision dual handwheel wormgear screwdown mechanism allows extremely accurate gage and camber control and is equipped with a quick-acting opening device used in threading the strip through the mill. In the backup-driven arrangement of the machine, the work rolls, which are made either of alloy steel or tungsten carbide, can be changed within one minute. For purposes of pass control, the mill may be equipped with continuous gages indicating roll separating force, strip tensions and stock thickness.

STEEL MILL USES FIBERGLAS SKYLIGHTS



The Atlantic Steel Co.'s new rod and bar mill features skylights of shatterproof fiberglas produced by the Alsynite Co. of America. View shows main mill building in foreground.

BLOWPIPE

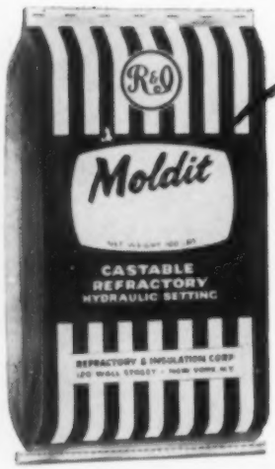
▲ Risers which weigh anywhere from 20 lb to as much as 400,000 lb can be quickly removed by a single operator without moving the casting, by means of the "Oxweld C-63" developed by Linde Air Products Co.

The new blowpipe is unique in many respects. It has a larger cutting capacity than any other manual blowpipe in existence, and it is capable of cutting through steel as thick as 55 in. in a single pass. Far greater thicknesses can be cut in multi-pass operations. The blowpipe applies a tremendous amount of preheat to the surface to be cut. It needs no auxiliary preheat. This exceptional preheat capacity is made possible by the use of separate hose lines for preheat and cutting oxygen.

Instead of the conventional type of nozzle alignment, the unit has a specially designed head which locates the blowpipe nozzle off center from the center line of the blowpipe. This allows the operator to widen the kerf uniformly by simply rotating the blowpipe. Once the kerf is widened, the blowpipe itself can be inserted into the kerf in order to deepen the cut. This technique,

There's a **Moldit** castable refractory to meet your requirements—

for ✓ High Strength at high, medium or low temperatures.
✓ Maximum Resistance to erosion, slag, water.
✓ High Insulating Value.
✓ Lower Cost Installation.
✓ Long Service Life.
✓ Low Cost Special Shapes.



12 *different Moldit Castables*

each meeting a special combination of working temperature, physical resistance, weight and strength requirements.

When you select a Moldit Castable you are sure of a refractory lining or shape best qualified to meet specific service needs at lowest overall cost. That's the reason for Moldit's outstanding reputation for highest quality to withstand severe processing conditions.

To help you, the new Moldit bulletin provides complete data on properties, thermal and physical characteristics, and how to use in blast furnaces, ladles, ingot molds, open hearth furnaces, soaking pits and annealing furnaces. Write for a copy today.

REFRACTORY & INSULATION CORP.
R&I
REFRACTORY BONDING AND CASTABLE CEMENTS
INSULATING BLOCK, BLANKETS AND CEMENTS
136 WALL STREET • NEW YORK 5, N. Y.

employing extremely large preheat and up to 9000 cu ft per hour of cutting oxygen, enables the blowpipe to cut through the heaviest of sections.

The blowpipe utilizes a cartridge type mixer which assures thorough mixing of gases. The length of the blowpipe can be altered to match job requirements. The blowpipe is adaptable to all industries where heavy sections of metal must be cut, including the shipbuilding, scrapping, and railroad industries.

MOTORS

▲ Announced by General Electric Co.'s General Purpose Motor Department is a complete line of instantly reversible door-operator motors, specially insulated to resist moist-air conditions for commercial, industrial, and domestic applications.

Instantly reversible and reversing-from-standstill models are included

Instantly reversible door-operator motor is specially insulated to resist moist-air conditions.

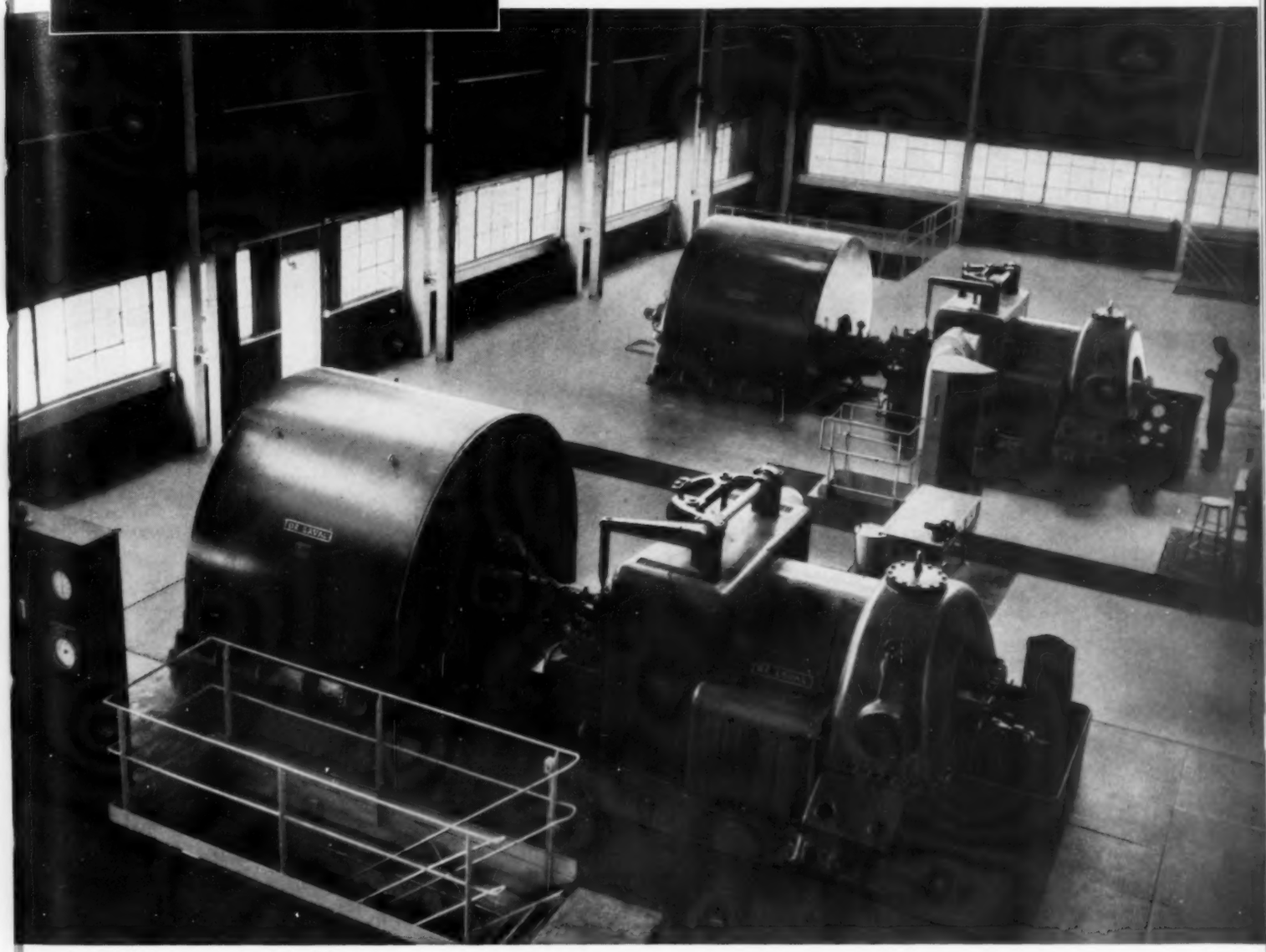
in the line of Form G motors. At 1725 rpm, ratings from ⅙- through ¾-hp provide power for door types ranging from light-duty through heavy-duty commercial and industrial doors.

Designed for operation in any position, the motor has all-angle sleeve bearings and a lubrication system that prevents oil loss even when mounted vertically. For further versatility, the motor can be rotated in its base to meet mounting requirements. To provide virtually noiseless motor operation, resilient mountings are also available.

DE LAVAL

BLAST FURNACE BLOWERS

deliver 110,000 cfm each for McLouth Steel



These two De Laval turbine-driven centrifugal blowers do a round-the-clock job in the McLouth Steel plant, Trenton, Michigan. Each has a rated capacity of 110,000 cfm of air; discharge pressure is 30 psig. Each is driven by a 12,400 hp, 2950 rpm De Laval steam turbine operating under steam conditions of 600 psig, 825 F with 2″ hg.

De Laval compressors are designed individually for each application to assure maximum efficiency and range of operation. Construction is rugged throughout. Casings and perfectly balanced rotors are built to take punishment. All parts are precision-made to limit gages. Materials are selected which will best meet the particular conditions of corrosion, pressure and temperature.

De Laval centrifugal blowers are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem.

Send for Bulletin 0504

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY

870 Nottingham Way, Trenton 2, New Jersey

Life tests carried out on the internal reversing switch in the motor indicate a switch life in excess of 20 years on door operator applications under normal operating conditions.

The complete line of motors is available in either instantly reversing or reversing-from-standstill models, with 3- or 5-lead design in the instantly reversing models and with 4-lead standard and 3-lead balanced-winding designs in models which reverse from standstill.

CONNECTORS

▲ Aluminum Co. of America has developed a new series of electrical connectors which makes possible a major reduction of conductor clamp inventories. Heavy-duty U-bolt clamps, employing universal, parallel spacer grooves, now can be used on a wide range of cable sizes.

The six clamps, designated 580 Series, can be used on ACSR from #2 to 715.5 MCM, and will also handle sizes #2 to 800 MCM stranded aluminum conductor. All proportions—length of clamps, number of bolts, bolt sizes—are engineered for the range of conductor

size to be accommodated and the job to be done. The U-bolt portion, flattened to reduce bulk, provides wrap-around strength and even pressure distribution.

Easy to install and maintenance-free, the clamps' generous dimensions impart added strength and reliability. Paramount qualities of resistance to corrosion and long life are assured by all-aluminum construction.

Proven during many months of Alcoa laboratory testing, the clamps have undergone a thousand heat cycles using various conductor combinations. Test currents produced conductor temperatures of 200 F, with no significant change in connection resistance.

GREASE

▲ A multi-purpose grease with an improved lithium base engineered to meet nearly all industrial lubrication requirements is now available from Gulf Oil Corp.

The new product—"Gulfcrown Grease"—is designed to provide superior lubrication under conditions which often require a variety of special greases. Among such conditions are high and low temperatures, the action of water, high-speed bearing action, and long storage.

The company points out that the single-product multi-purpose grease reduces errors in application, cuts lubrication costs, reduces the number of grease guns needed, and

GENERAL ELECTRIC ANNOUNCES . . .

NEW 50,000-KVA E-1 MOTOR STARTER

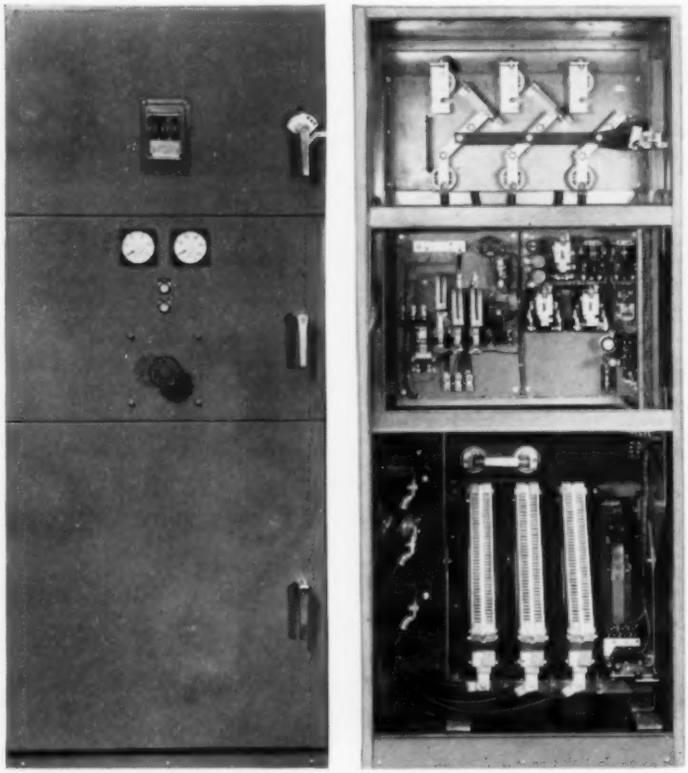
General Electric's all new 50,000-kva, air-break motor starter utilizes the 50-mva interrupting ability of its contactor for fault interruption. This new Class E-1 starter combines dependable performance with these other outstanding features:

- **Increased Personnel Safety**—entrance to the high-voltage compartments is impossible until the unit has been de-energized.
- **Easy Installation**—contactor may be rolled in or out of unit, and all connections are made from front.
- **Space Savings**—small cabinet (30 in. deep, 38 in. wide, 90 in. high) plus elimination of need for back aisle.

This new General Electric starter is designed to handle 2300 to 4600 volts for motors up to 3000 hp. Unit contains no power fuses; however, for interrupting capacities over 50,000 kva, fuses can be added.

Contact your G-E Apparatus Sales Office, or write Sect. 783-5, General Electric Co., Schenectady, N. Y.
Industry Control Department, Roanoke, Virginia.

GENERAL ELECTRIC



New G-E starter provides 50-mva interrupting capacity without fuses, increases personnel safety, minimizes floor-space needs.

Charging Box Cars

USS-DESIGNED

to your specifications

United States Steel can build any type of industrial car that is needed in today's modern steel plants. Our staff of engineers specializes in designing cars that meet users' specifications and service requirements.

The four-unit charging-box car, illustrated here, is a good example of a USS-Designed Car. This all-welded steel car has a capacity of 25 tons, and is built for standard gage track. The running gear of this heavy-duty, four-wheel industrial car is equipped with outboard, anti-friction bearings. Car weight, when empty, is 20,300 pounds.

Capacity, running gear, and other design features can be varied to meet your specific needs. In other words, all USS Industrial Cars are custom-made.

Our engineers will be pleased to call at your plant to discuss your requirements for industrial cars. Meanwhile, send for a free copy of our 32-page illustrated booklet—"USS Custom Designed Cars."

Completed charging box car has 25-ton capacity. It is 7′ 4″ wide x 15′ 7″ long, on an 84″ wheelbase.

Welding underside of car. Steel plate of all-welded car is ¾″ to 1¼″ thick. Side plates and deck are 1″ steel; end plates are 1¼″.

Checking thickness of steel underframe. Longitudinal members are 1″ plate and the spacers are ¾″ plate.

USS INDUSTRIAL CARS

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

United States Steel Corporation
525 William Penn Place, Room 2801
Pittsburgh 30, Pennsylvania

Please send me a free copy of your 32-page booklet, "USS Custom Designed Cars."

Name .....

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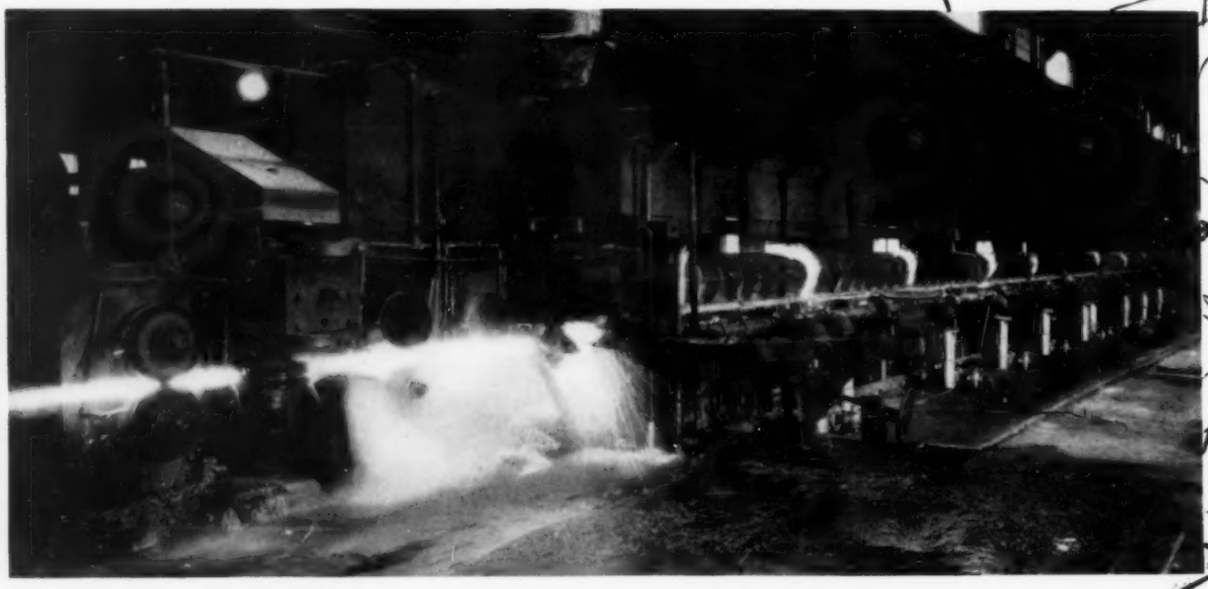
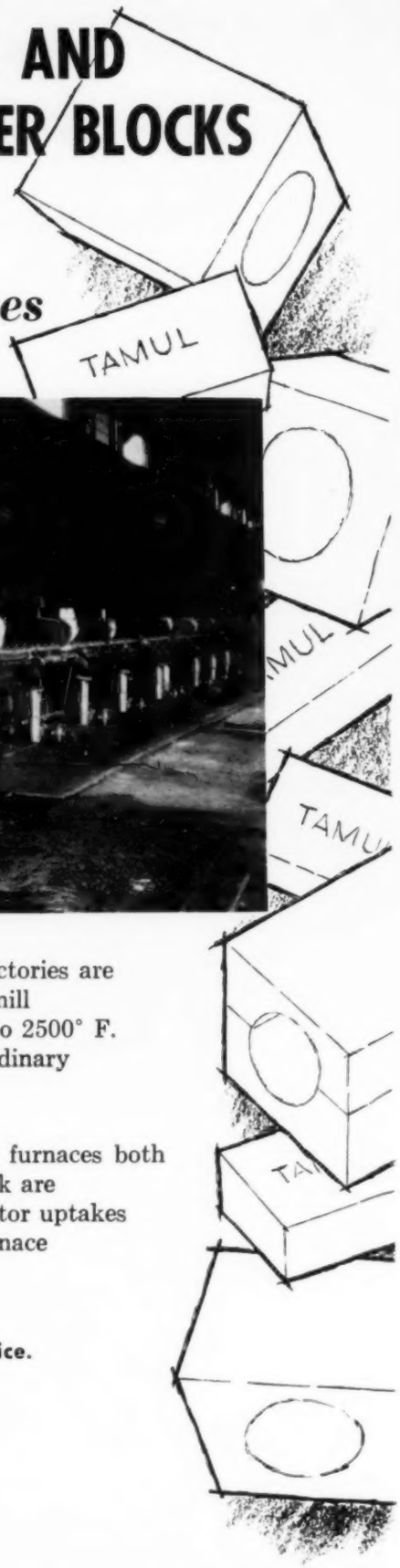
TAMUL BRICK AND BURNER BLOCKS

speed production in continuous pipe mill furnaces





TAMUL® (Taylor sintered synthetic mullite) refractories are preferred by operators of continuous butt-weld pipe mill furnaces*. Heating cold skelp for ½" diameter pipe to 2500° F. in 21 seconds produces furnace conditions in which ordinary refractories quickly fail.

TAMUL burner blocks are regularly used in these furnaces both on original installations and on repairs. TAMUL brick are installed in the inner linings of side walls, in recuperator uptakes and in the bungs. This condition results in longer furnace campaigns because TAMUL has:

- **High softening point.**
- **Freedom from shrinkage in service.**
- **High hot load strength.**
- **Good resistance to slagging.**

* *Engineered and built by Salem-Brosius, Inc., Pittsburgh, Pa.*

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
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TAYLOR ZIRCON TAYLOR SILLIMANITE

The CHAS. TAYLOR SONS Co.
A SUBSIDIARY OF NATIONAL LEAD COMPANY
REG. U. S. PAT. OFF.
REFRACTORIES SINCE 1864 • CINCINNATI • OHIO • U. S. A.

CRYSTAL GAZER

Electron microscope at the new U. S. Steel Research Center, Monroeville, Pa., can probe a minute area about 1/25,000 of an in. in cross section. Even variations in the steel on the edge of a razor blade are revealed. This is done by focusing a beam of electrons on the tiny zone.

simplifies problems of storage, handling, and inventory.

Features of the new lubricant include high oxidation stability which provides longer life both in use and in storage; high mechanical stability which keeps the grease from thinning and running out of bearings; high resistance to the washing action of water which provides continued lubrication under the dampest conditions. It also provides effective protection against rust; ready flow in cold weather.

In a demonstration of the oxidation-resistance qualities of the new lithium-base grease, the company ran bearings packed with "Gulfcrown" at 750 rpm in a special oven heated to 250 F. The company reports that after several thousand hours the lubricant had not hardened or "coked up" and the bearings remained in "brand new" condition.

The company also reports that samples of the new grease pump easily while being stored for days in a freezer chest at zero temperature, and that the grease does not break down in consistency when pumped through a bearing operating at 1725 rpm.

In another demonstration, samples of the grease were placed on steel plates and sprayed for several hours with water heated to 130 F. The company states that the grease adhered to the plates throughout the demonstration and did not wash away.

The new grease, which is available in four consistencies, can be applied equally well by grease guns or through a centralized lubrication system.

POTENTIOMETER UNIT

A new self-balancing electronic potentiometer servo-mechanism has recently been made available by The Bristol Co. The unit is furnished without a case, and is designed to be built into a user's equipment.

The mechanism consists of a group of standard Dynamaster instrument parts assembled on a circular base, and fitted with an indicating scale. When used with a Bristol amplifier, input transformer, and Synchroverter d-c, a-c inverter, it forms a complete self-balancing

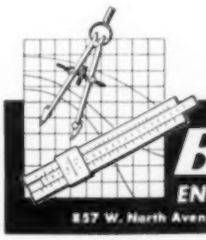
The BLOOM Time-Cycle Reversal Unit

assures FULL, FAST AND EFFICIENT REVERSAL OF REGENERATIVE FURNACES AUTOMATICALLY

This complete, compact, factory-tested unit provides a combination electric-pneumatic system for Open Hearth Furnace and Soaking Pit reversal. It elimnates reversal puffing and shortens reversal period. (10 to 15 seconds easily accomplished).

Shorter reversal cycle improves furnace life.

These units have been in continuous service for nine years. Trouble-free maintenance.



BLOOM ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

WRITE or phone for complete information on the Bloom Time-Cycle Reversal Unit.

dial indicator. The unit is available as a potentiometer or as an a-c bridge. Dial indicator speeds of 1 second, 3 seconds, and 4½ seconds are offered, and one blind set alarm switch can be furnished. The unit can also be supplied with a retransmitting slidewire.

Applications for the new servomechanism include use as a low-cost indicating pyrometer, resistance thermometer, or potentiometer to be incorporated into user's equipment; as a replacement for a direct deflecting d-c milliammeter or millivoltmeter, where better accuracy or reliability is required; or for use as a self-balancing unit to operate analog-to-digital conversion mechanisms for readout.

DRAW BENCH

▲ Production of drawn welded steel tubing at the Steel and Tubes Division of Republic Steel Corp. has been increased as a result of the installation of a new 100,000-lb multiple bench capable of cold drawing tubing in sizes from ¾ in. O.D. to 5 in. O.D.

For larger size and heavier gage tubing the machine is operated as a single draw bench. With medium size work, two or three tubes are drawn simultaneously.

Equipped for either "sink" or "mandrel" drawing, the bench is a modern design, single chain type with block carriage. It is so set up that alternate carriage blocks with single, double, or triple grips can be used. Corresponding changeable die blocks permit single, double or triple draws as the work requires. This may involve drawing to obtain specific O.D. or I.D. size, wall thickness or possibly a change of physical properties, as well as furnishing special smooth I.D. surfaces.

The bench provides a flexibility of operation for producing extremely close tolerances and other than standard shapes, particularly in the larger sizes and heavier wall thicknesses.

A variable voltage type drive of 200 hp permits drawing speeds to be adjusted over a wide range for maximum efficiency. Mechanical loaders push the tubes over the rods when "mandrel drawing" and hydraulically operated unloading arms move the tubes to crane bucks.

A 5-in. Stevens and Bullivant pointing swager provides added pointing capacity for both medium and larger sizes. In this type of machine the work and swager dies do not rotate. By this combination of features, the swager is able to produce a sharp taper on the end of the tube and thereby reduces the length of the point. Also, since the tube remains stationary, surface scratches are reduced in the pointing operation. The pointer is driven by a 40 hp a-c motor.

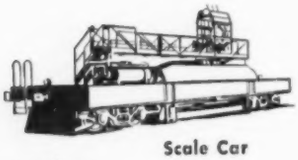
PRECIPITATOR SERVICE

▲ A service program for regular inspection and maintenance of electrostatic precipitators in the steel industry has been introduced by Premsco, Inc., a newly formed organization in Ashland, Ohio.

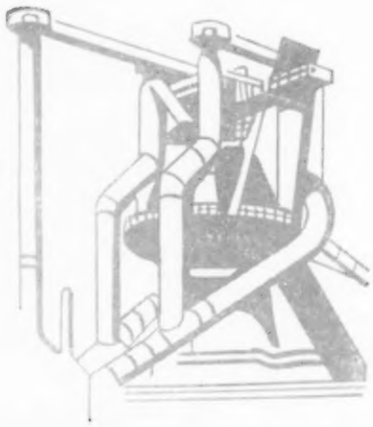
Premsco will furnish a steel mill, on a contract basis, with a regular periodic inspection, a cleaning and rehabilitation program to keep precipitators operating at peak efficiency. The company offers a complete mobile service unit and trained specialists to do the service work.

The service calls for a two part program: (1) regular inspection and

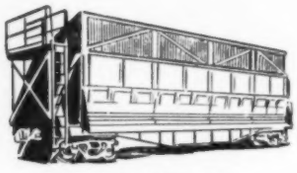
WHEREVER *performance* COUNTS



Scale Car



100-ton Ore Transfer Double Compartment, Bottom Dump



Coke Quenching Car

Atlas Cars are built to resist the high wear factors of continuous service handling abrasive materials. Extra factors of safety in brakes, controls, visibility, and signal devices are incorporated for foolproof service.

Each car is engineered to meet the operating needs of the plant where it will be used.

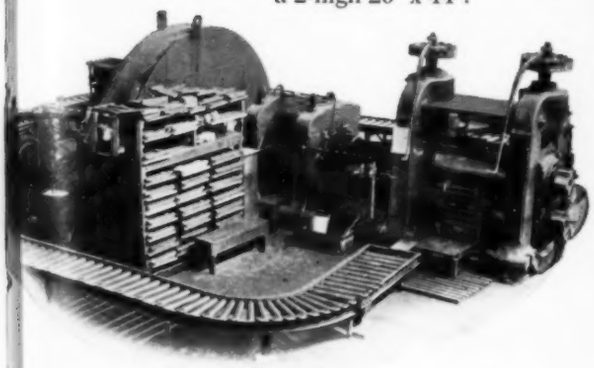
ATLAS CAR & MFG. CO.
1100 IVANHOE ROAD
CLEVELAND 10, OHIO

Consult Atlas for your Steel Plant Cars

ENGINEERS AND MANUFACTURERS SINCE 1896

BEFORE

Falco's #5 mill, as it looked before modernization. It is a 2-high 20" x 44".



AT FAIRMONT ALUMINUM

Same mills... big differences

Without running any faster, this line of cold mills has 20% greater capacity, thanks to BLISS modernization

RESULTS

Here's what Fairmont Aluminum reports about its Bliss-modernized mills:

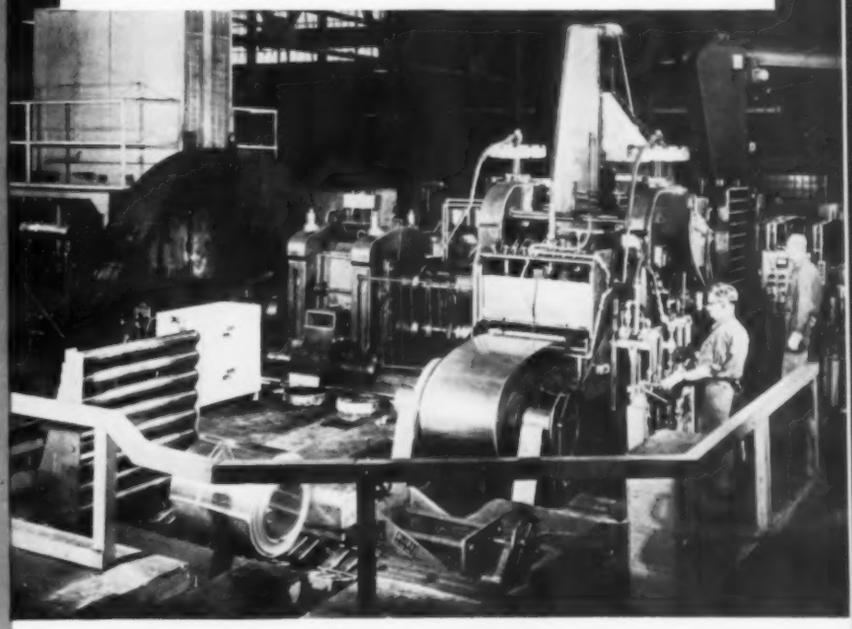
- Output is up 20% and will go higher as the plant completes other installations, such as new annealing facilities.

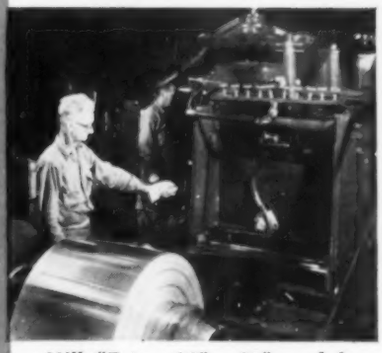
- Coil handling is far easier. Surface damage to the strip has been eliminated. And finish has been improved by the new roll-coolant systems ... Fairmont Aluminum formerly dry rolled.

- Thanks to the new Bliss tension reels, reduction per pass on each mill has been increased 12% or more. Former maximum was 20%.

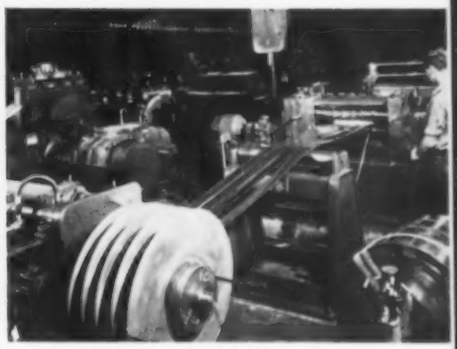
AFTER

The same mill, as it looks today. The entry and delivery equipment has been replaced with Bliss cone-type payoff reel, tension reel, bridle unit, belt wrapper, coil buggies and upenders. The strip is accurately centered in the work rolls, and it is a simple matter to hold gage, always a problem with the old equipment. This mill is used for secondary breakdown, rolling strip in thicknesses between 0.125" and .025" and in widths to 38". Similar Bliss equipment was also added to Mill #6, used for secondary breakdown and finishing of narrower strip. Another improvement involves new motorized screwdowns presently being manufactured by Bliss.





Mill #7 is a 16" x 30" used for finishing to gages as thin as .006". It has a Bliss mandrel-type payoff (shown here), bridle feed, tension reel and roll-coolant system.



New 28" Bliss slitting line takes up to 12 cuts in 0.020" material at speeds up to 600 fpm. Bliss also revamped the plant's 36" slitting line, equipping it with tension reel, mandrel-type payoff and coil buggy.

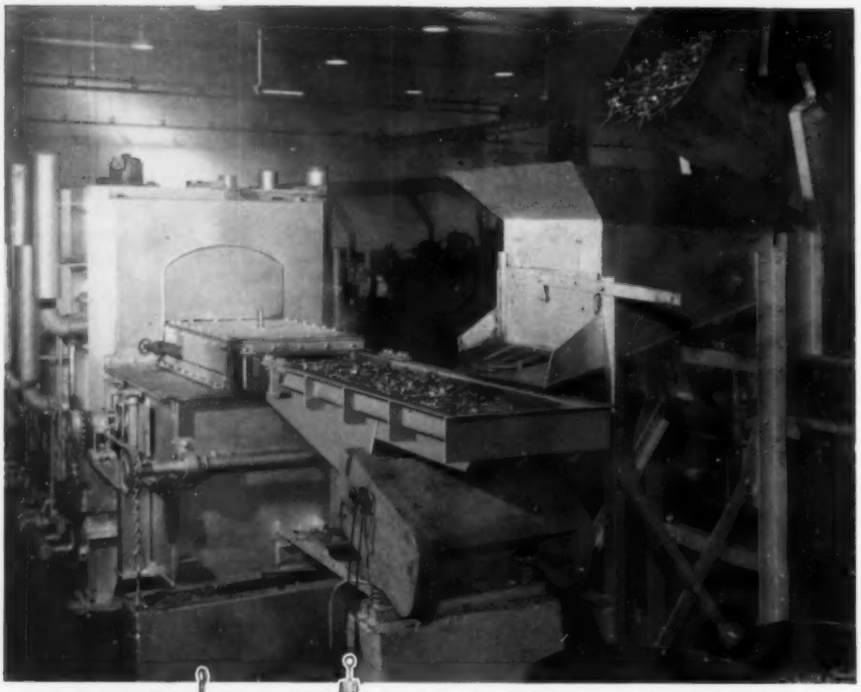
If you are contemplating improvements or modernization, it will pay you to consult Bliss Rolling Mill Division engineers. For details of typical Bliss installations, write today for a copy of the 60-page Bliss Rolling Mill Brochure, Catalog 40-A. It's yours for the asking.

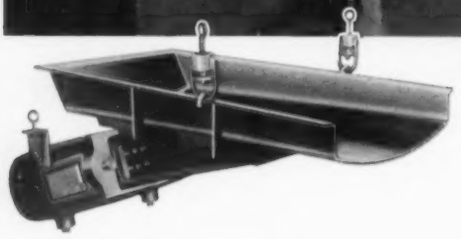
BLISS
SINCE 1857 ®

is more than a name... it's a guarantee

E. W. BLISS COMPANY
General Office: Canton, Ohio
ROLLING MILL DIVISION, Salem, Ohio

PLANTS: Canton, Cleveland, Salem and Toledo, Ohio; Detroit and Hastings, Michigan; Pittsburgh and Midland, Pennsylvania; San Jose, California. *In Europe:* E. W. Bliss (England) Ltd., Derby; E. W. Bliss Co., (Paris), France.





SYNTRON Vibratory Feeder feeding metal parts to continuous heat treating furnace.

SYNTRON
"Vibra-Flow"

VIBRATORY FEEDERS

SYNTRON "Vibra-Flow" Vibratory Feeders with variable control of materials flow will match the capacity of continuous operating equipment. The flow rate of SYNTRON Vibratory Feeders is instantly adjustable, from minimum to maximum to meet production schedules.

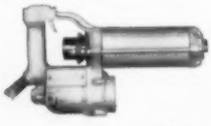
SYNTRON Vibratory Feeders are applicable to most any materials handling problem. They provide a smooth, even flow of sand, slag, ore, scrap, and finished products to conveyor belts, plating baskets, heat treating furnaces and other types of equipment.

Increase production and lower operation costs by including SYNTRON Vibratory Feeders in your operation. Send us details of your materials handling problem—Our application engineers will be glad to make recommendations.

Other SYNTRON Equipment of proven Dependable Quality

POWER CONVERSION UNITS

ELECTRIC HAMMERS



VIBRATING SCREENS

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SYNTRON COMPANY
699 Lexington Avenue Homer City, Penna.

cleaning of precipitator interiors, the removal of loose scale and rust within the operating confines and the inspection, cleaning and adjustment of component parts, and (2) adjustment and inspection of all electrical and exterior parts.

In the cleaning and servicing of precipitators, the company uses a mobile service truck. The truck is equipped with both high-pressure and high-capacity pumps, welding units, chemicals and acids used in cleaning processes, and operates on its own generator. Servicemen accompany the trucks and perform the work. The steel mill furnishes only the water and steam used in cleaning.

MASONRY SAW

▲ The Clipper Manufacturing Co. announces "Supermatic"—a new masonry saw.

The saw features a "Hi-Lo" control wheel which does everything quickly and safely, without the operator having to turn off the motor. It keeps the cutting head level, ready to cut at any height. There are no levers or knobs to pull, no blade guard or head angle adjustments to make—and the saw is always in perfect alignment. The control wheel sets the cutting head so the operator cannot cut through the conveyor cart or damage blades. It automatically makes all adjustments.

The saw is a wet or dry masonry saw and can be quickly converted to a light duty concrete saw and a track saw. Frame extensions can be added to increase the saw width up to 6 ft, to cut sills, copings, and large stone and masonry units.

GATE VALVES

▲ Longer end-to-end dimensions for its cast steel gate valves for butt welding have been announced by Crane Co.

The increase applies to Crane's 150-lb. cast steel gate valves in sizes from 2 in. through 24 in.

The increase in dimension will offer greater protection to seating areas against heat distortion during the welding of line connections. The new and longer dimensions comply with proposed ASA Standard B16.10, given approval by the Manufacturers Standardization Society of the Valve and Fitting Industry.

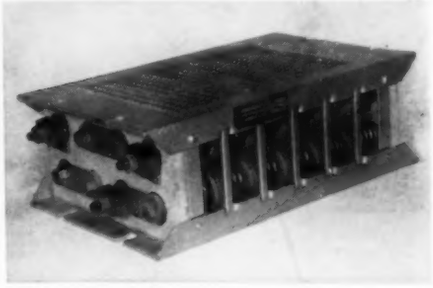
GUYAN
RESISTORS

Engineered and designed to eliminate resistor maintenance on troublesome mill applications.

Non-breakable helical coil construction ends burnouts due to warping and buckling of grids.

Sturdy, rugged steel construction eliminates shock and vibration troubles.

Custom designed for your conditions including excessive graphite accumulations.



With a quarter century of resistor engineering, we invite you to take advantage of our experience.

For complete information on Guyan Resistors, please contact the nearby Guyan Representative or our main plant at Logan, W. Va.

Baltimore, Md.—Durling Electric Co., 2505 St. Paul St.

Birmingham, Ala.—Ebbert & Kirkman Co., 2313 6th Ave. So.

Buffalo, N.Y.—Buffalo Electric Co. West Mohawk St.

Chicago, Ill.—John K. Byrne, 1515 W. Howard St.

Cleveland, Ohio—Mechanical Equipment Co., 3100 Prospect Ave.

Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

Philadelphia, Pa.—George I. Wright 811 Commercial Trust Bldg.

Pittsburgh 27, Pa.—P. R. Holden, 4860 Elmwood Dr.

●

GUYAN MACHINERY COMPANY

LOGAN, W. VA.

A 2-in. valve will now measure 8½ in. end-to-end, a 10-in. valve 18 in. end-to-end, and a 24-in. valve 32 in. end-to-end.

SOLDER

▲ A new self-annealing tin base solder which offers unusually high creep strength, yet can be applied at substantially lower temperatures than silver solders and brazing alloys, 428-435 F, has been announced by Alpha Metals, Inc.

Called #38 alloy, the solder has been successfully tested in several applications requiring high creep strength, such as soldering flanges to the barrels of wave guides. Test data indicate that the use of this material in such applications, in addition to its strength, eliminates the possibility of distortion generally resulting from excessive heat, and it also ends low conductivity problems caused by oxide films produced from brazing fluxes.

The solder is a lustrous alloy, matching stainless steel in appearance, which flows and has good wetting properties. While the creep strength is less than that of silver solders, it is high enough at the usual stress loads to withstand creep for indefinite periods of time.

The alloy is available in diameters of .032 to .125 of solid wire, and may be heated by iron, resistance tools, flame or induction heating.

TRANSFER UNIT

▲ Development of a new portable mechanical transfer unit that converts any standard press into an automated press capable of handling a number of progressive operations and a broader range of sizes was announced by the Sheffield Corp.

Completely mechanical in operation, the new Sheffield "Press Pacer" is a portable unit that transfers stampings from one die station to the next on each stroke of the ram. It can also be used to transfer parts between presses.

Tests have shown the "Press Pacer" enables one press to do the work of several, making possible tremendous reductions in capital investment, labor and space requirements, it was pointed out. In one test, use of the versatile new unit cut the required number of presses

Hyde Park

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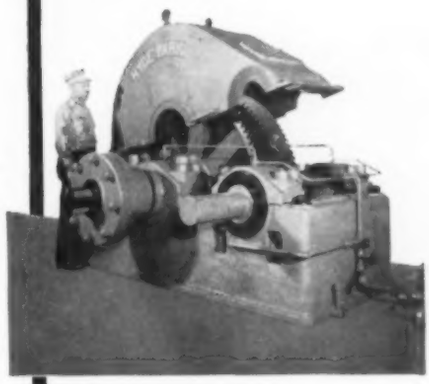
Hyde Park Castings up to 80,000 pounds are sound, accurate and physically dependable.
Precision machining is done by skilled craftsmen in our modern machine shop.
Send your blue prints for quotation.



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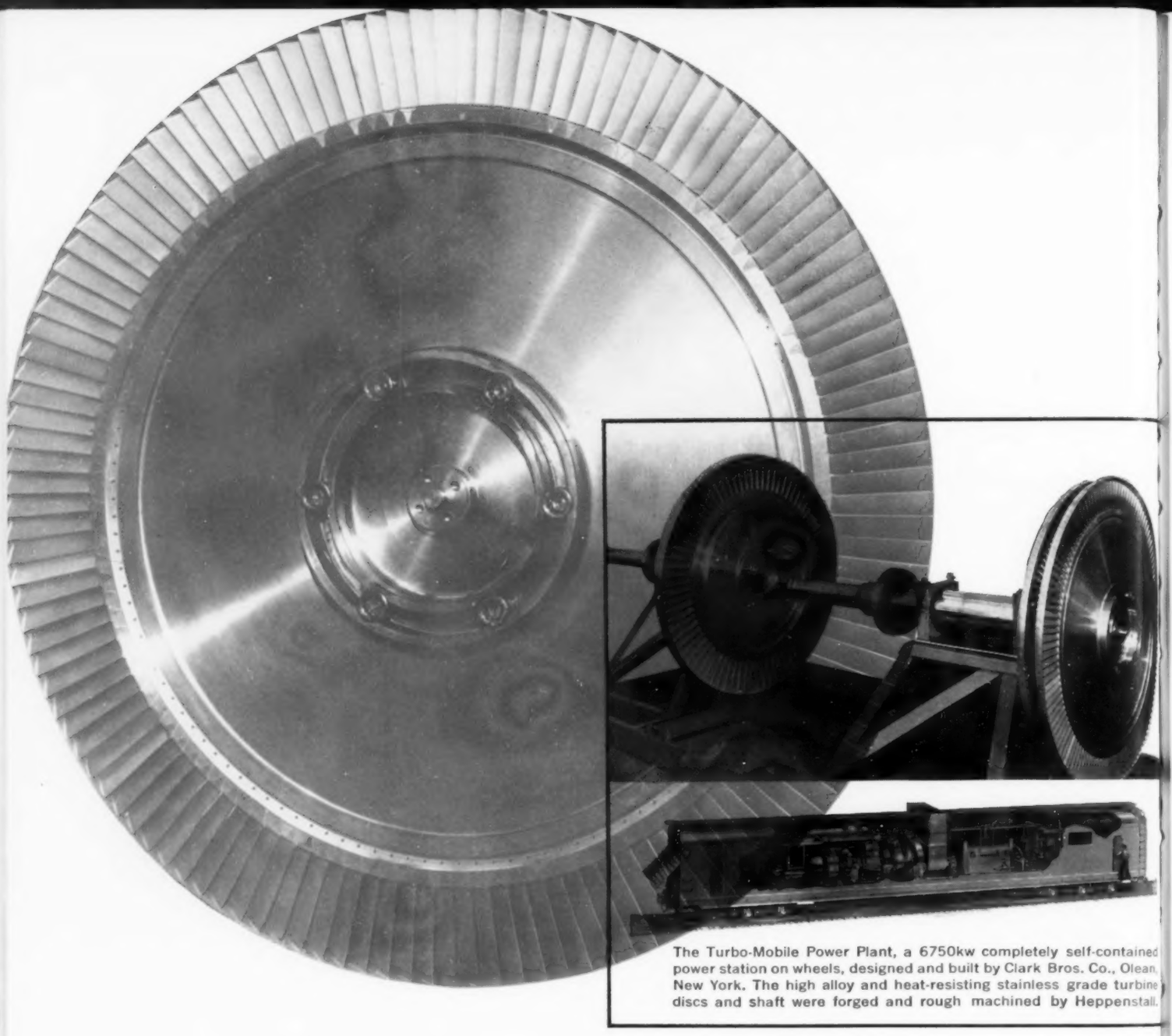


The Turbo-Mobile Power Plant, a 6750kw completely self-contained power station on wheels, designed and built by Clark Bros. Co., Olean, New York. The high alloy and heat-resisting stainless grade turbine discs and shaft were forged and rough machined by Heppenstall.

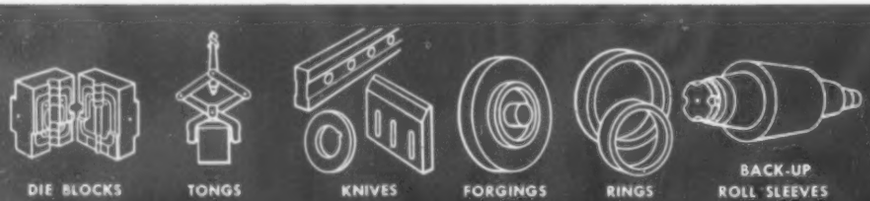
Heppenstall Forgings add reliability to Clark Power Plant Gas Turbine discs

Ingenious design and engineering have solved the problem of rapid restoration of power following natural disasters and war damage . . . or temporary power for fast growing residential or industrial areas. A Clark 6750kw gas turbine power plant can now roll in at normal rail speeds and put power on the line in the little time required to connect fuel and power outlet lines. It *must* be dependable, that's why the turbine discs used in driving the axial compressor and generator are Heppenstall Forgings.

Heppenstall Forgings, in any shape you may require, are made from special Heppenstall open hearth carbon and alloy steels, or high alloy and heat resisting stainless steels from Heppenstall Electric Induction Furnaces.

These Forgings must pass rigid inspection and ultrasonic testing . . . your assurance that each Heppenstall Forging becomes a trouble-free component of your product. And the satisfied user becomes a steady customer.

For the full story of how Heppenstall Forgings can build quality and performance into *your* product . . . and your production machines . . . contact your Heppenstall Company Representative.



HEPPENSTALL

... the most dependable name in forgin

PITTSBURGH 1, PENNSYLVANIA

from six to one and total productivity was boosted three to four times. The unit improved quality substantially by completely eliminating damage to workpieces previously caused by moving pieces from one press to another.

The unit is completely mechanical in operation. There are no electrical, pneumatic or hydraulic connections or movements.

The "Press Pacer" is capable of moving parts through a number of die operations such as blank, draw, pierce and trim simultaneously.

The "Press Pacer" is adjustable for different spacings between dies and also for different ram strokes. It can be installed to run either front to back or left to right. The unit is bolted to the bed of the press.

The minimum size press in which the standard model can be used has a bed area approximately 42 x 72 in. and a 14 in. shut height.

NOZZLES

▲Spraying Systems Co., has introduced a new design full-jet nozzle with pull-out vane. The vane of this nozzle is made with a small female threaded connection to receive a pull-out rod, to be installed by the user in whatever length required. The rod extends back inside the pipe to some connection point that is easily accessible. When cleaning is needed the vane is merely drawn back through the pipe, and removed and cleaned while the nozzle itself is flushed out.

This new nozzle is supplied in a range of sizes and capacities.

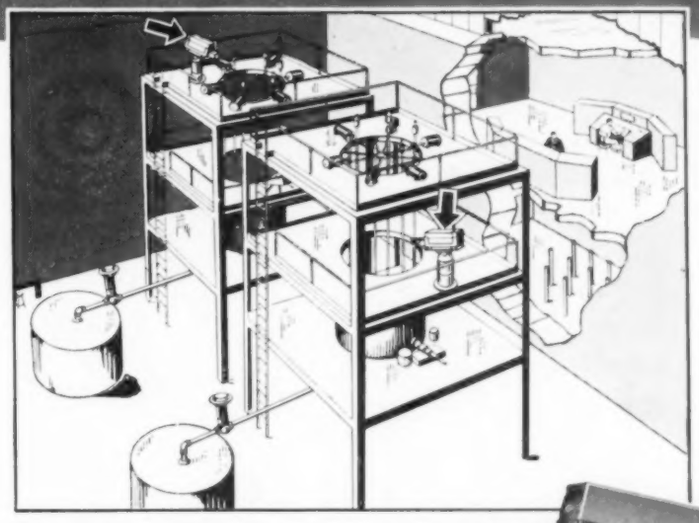
BLENDING PROCESS

▲A new method of mixing and blending bulk materials to produce a uniformly homogeneous mixture in a continuous flow has been developed by Hewitt-Robins, Inc. The system is expected to be especially useful in blending coking coal for steel blast furnaces.

The blending is done in a metal or concrete bin containing a series of overlapping baffles which deflect the out-flow to the sides of the container.

Material to be blended is layered into the bin by a conventional belt conveyor tripper on top of a rectangular bin or a simple chute in the case of a cylindrical bin. While

Diamond "UtiliVue" (WIRED TELEVISION) used in NUCLEAR REACTOR STUDIES at Battelle Memorial Institute



Arrows indicate remotely controlled "UtiliVue" Cameras that SEE experimental nuclear reactor cores.

"UtiliVue" Monitor is built into control console in separate control room where experimental nuclear reactor cores can be WATCHED in perfect safety.

"UtiliVue" pedestal enables camera to be rotated 320° and tilted 90° by remote control from console. Zoom lens (also controlled from console) brings objects into focus at widely varying distances from camera.

The "UtiliVue" is invaluable whenever there is the need for actually SEEING what is happening where it is impossible or impractical for the human eye to watch directly. There are installations of Diamond Industrial TV that have been in continuous operation since 1946. For further information, get in touch with your Graybar Distributor or use the coupon below.

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the bin is being emptied from the bottom the incoming material is directed into the side chute section in a continuous series of small increments from top to bottom. Blending thus takes place automatically as small portions of each layer enter the chute area and flow downward by gravity. At the bottom of the bin, the material is removed from the outlet shelf by a plow or similar device and taken away by belt conveyor.

The bin can be built any size, depending on the volume of material to be blended. After the bin has been filled, the blending process is carried on continuously by regulating the rate of input to match the rate of drawoff so that material flows through the bin at a steady rate.

FISH TAPE LEADER

▲Made of special high tempered steel, precision ground, the new Barth Corp. tapered "Snake Charmer" leader possesses the great flexibility of a fly rod—stiff at one end for pushing strength and flexible at the other end to promote the correct twist at reverse elbows.

Available in two sizes, the unit fits $^1/_8$ in. and $^1/_4$ in. tapes by means of a sleeve equipped with a set screw. The opposite end of the leader is fitted with a tapered ball which provides a bearing to lead the tape through the most intricate series of elbows and bends. The leader is individually packed in a plastic carrying case with instructions.

Book Reviews

"ASTM Methods for Chemical Analysis of Metals," 1956 edition, has recently been published by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. The book contains 640 pages, 6 x 9 in., is cloth bound and sells for $8.00. This is the first complete revision of the volume since 1950 and contains all ASTM methods for chemical analysis of ferrous and non-ferrous metals and alloys, including spectrochemical procedures. It complements Part 1 on Ferrous Metals and Part 2 on Non-Ferrous Metals of the Society's Book of Standards, and contains ten completely new methods and recommended procedures, including chemical analyses for electronic nickel and titanium and two important recommended practices in spectrochemical analysis. It contains the latest standards (10 of which have been substantially revised since 1950) formulated by Committee E-3 on Chemical Analysis of Metals and Committee E-2 on Emission Spectroscopy, as well as 42 methods of analysis including four spectrochemical procedures, five recommended practices and one specification. Some of the standards contain comprehensive diagrams of apparatus and pertinent charts.

"Engineering Structural Failures," by Rolt Hammond has recently been published by the Philosophical Library, 15 East 40th Street, New York 16, N. Y. The book contains 224 pages, 6 x 9 in., is cloth bound and sells for $12.00. The book provides a useful survey of the causes and results of failures in a variety of structures considering, each in a chapter, earthworks, dams, maritime structures, buildings, bridges, underground structures, vibration problems and welded structures. The final chapter, lessons of failures, reviews modern methods of testing materials, ranging from X-ray and electronic developments to the very recent de Havilland aircraft pressure-test tank. Numerous line drawings and photographs support the text and many references are cited at the end of each chapter.

"Contracts, Specifications and Engineering Relations," third edition, by Daniel W. Mead (this edition rewritten by the staff of Mead and Hunt, Inc., consulting engineers and Joseph Reid Akerman), has recently been published by the McGraw-Hill Book Company, Inc., New York, N. Y. The book contains 427 pages, 6 x 9 in., is cloth bound and sells for $7.00. This third edition, written in an up-to-date style, follows the treatment originated by D. W. Mead, the original author. The text material has been reorganized to provide an up-to-date presentation; the sample reports and business letters have been rewritten for current usage, and the forms given as samples are the type currently used in business transactions. In the chapters dealing with legal matters, the language is chosen to be

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within the vocabulary of technical students, yet legal terms are used precisely. Numerous sections from actual specifications currently being used by consulting engineers and architectural firms are given as samples; and a complete set of specifications recently used by a consulting engineer for actual construction work has been included as an appendix. In this third edition much of the material in the original edition concerning detailed descriptions of materials useful in construction work has been deleted. Such information is now readily available elsewhere and a list of such societies and associations distributing such standard specifications for materials and processes has been included as Appendix B. Study and review questions follow each chapter.

"Friction and Lubrication," by F. P. Bowden and D. Tabor has recently been published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. The book contains 150 pages, 4 x 6 1/2 in., and is cloth bound. This book gives a brief account of modern work and views on the mechanism of friction and lubrication, treated nonmathematically and kept simple. Eleven chapters present and discuss the following phases: friction and its measurement; the nature of solid surfaces and the area of contact between them; adhesion, surface damage and the mechanism of friction; the breakdown of oxide films and the friction of clean surfaces; surface temperature of sliding solids; the friction of nonmetallic solids; rolling friction; hydrodynamic or fluid lubrication; boundary lubrication; the theory of boundary lubrication; extreme pressure lubrication. Numerous tables, line drawings and photographs support and explain the text.

"Architects' Details Sheets" (Third series of 96 selected sheets), edited by Edward D. Mills, has recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 232 pages, 11 1/2 x 9 in., is cloth bound, and sells for $12. Examples are all works of contemporary architects in various parts of the world, to show how architects combine good construction and appearance in buildings and structures of various kinds, emphasizing constructional applications of practical value, particularly in regard to walling, windows and entrances. Examples are arranged in appropriate groupings for ease of comparison and reference.

"Electronic Computers Principles and Applications," edited by T. E. Ivall, has recently been published by Philosophical Library, 15 East 40th Street, New York 16, N. Y. The book contains 167 pages, 8 1/2 x 5 1/2 in., is cloth bound, and sells for $10. The book is arranged in 11 chapters and starts with the evolution of computing, covering such aspects as the general principles of computing; analogue computer circuits; equipment and applications of analogue computers; digital computer circuits; basic arithmetic operations and control and general organization; storage systems; digital computer equipment; application of digital computers. It discusses computers of the future, presenting a reasonably broad picture of electronic computing. It is not presented as a book for computer experts, but

(Please turn to page 270)

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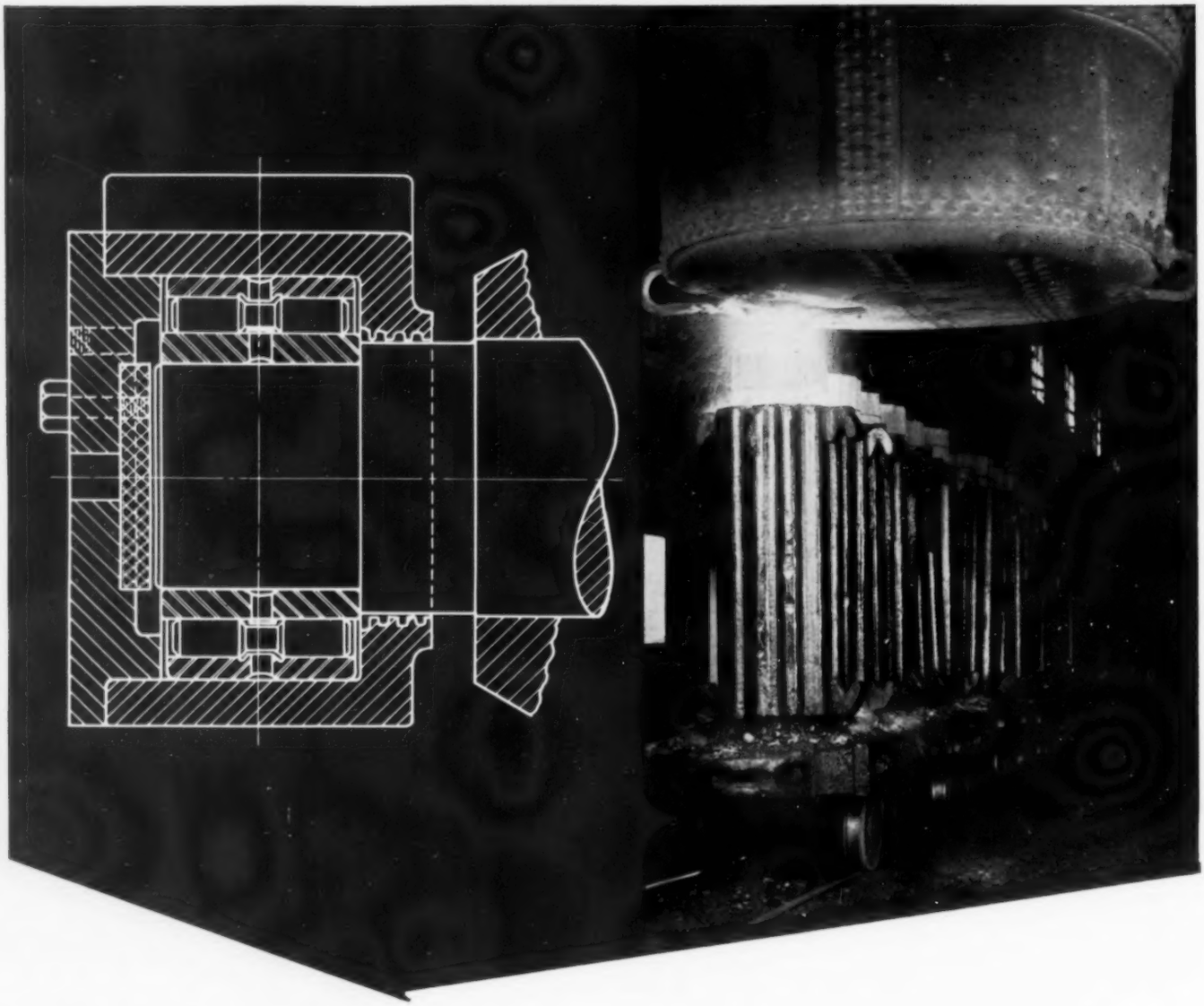

Bearings, Inc. engineering service . . . keeps ingot mold cars on the move

Ingot mold cars for a large tube mill were continually out of service due to the short life of babbitt, bronze or other bearings originally supplied in the cars.

The Trouble? Bearings, Inc. engineers found shock loads far beyond the capacities of the original bearings. Extreme wear on bearings due to excessive skewing, bent axles and uneven track.

The Answer. Shown above is the Bearings, Inc. drawing of the installation that replaced the original bearings. It has greatly increased load capacity and no dimensional change is required in the shaft or bearing housing.

The Result. The new bearing is designed on a new principle that keeps rollers in line and eliminates skewing. Shock loads due to uneven tracks have little effect on our installation for its construction makes possible a greater number of rollers available to support the load at all times.

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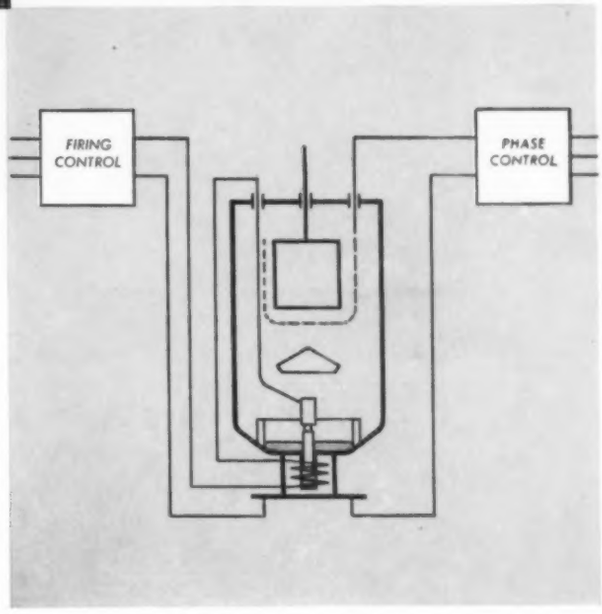
2. Phase Control Circuit

A separate circuit utilizes the deionizing grid to obtain phase control. Grid-type phase control permits operation in the clean region near the anode where ion density is lowest, instead of on the surface of the cathode mercury pool where there is turbulence and contamination. Reliability of phase control does not depend on the condition of the mercury. This is an exclusive excitron feature.



Only Excitron Rectifiers Provide Separate Circuits

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For Complete Information on rectifier operation, call your nearby A-C office, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

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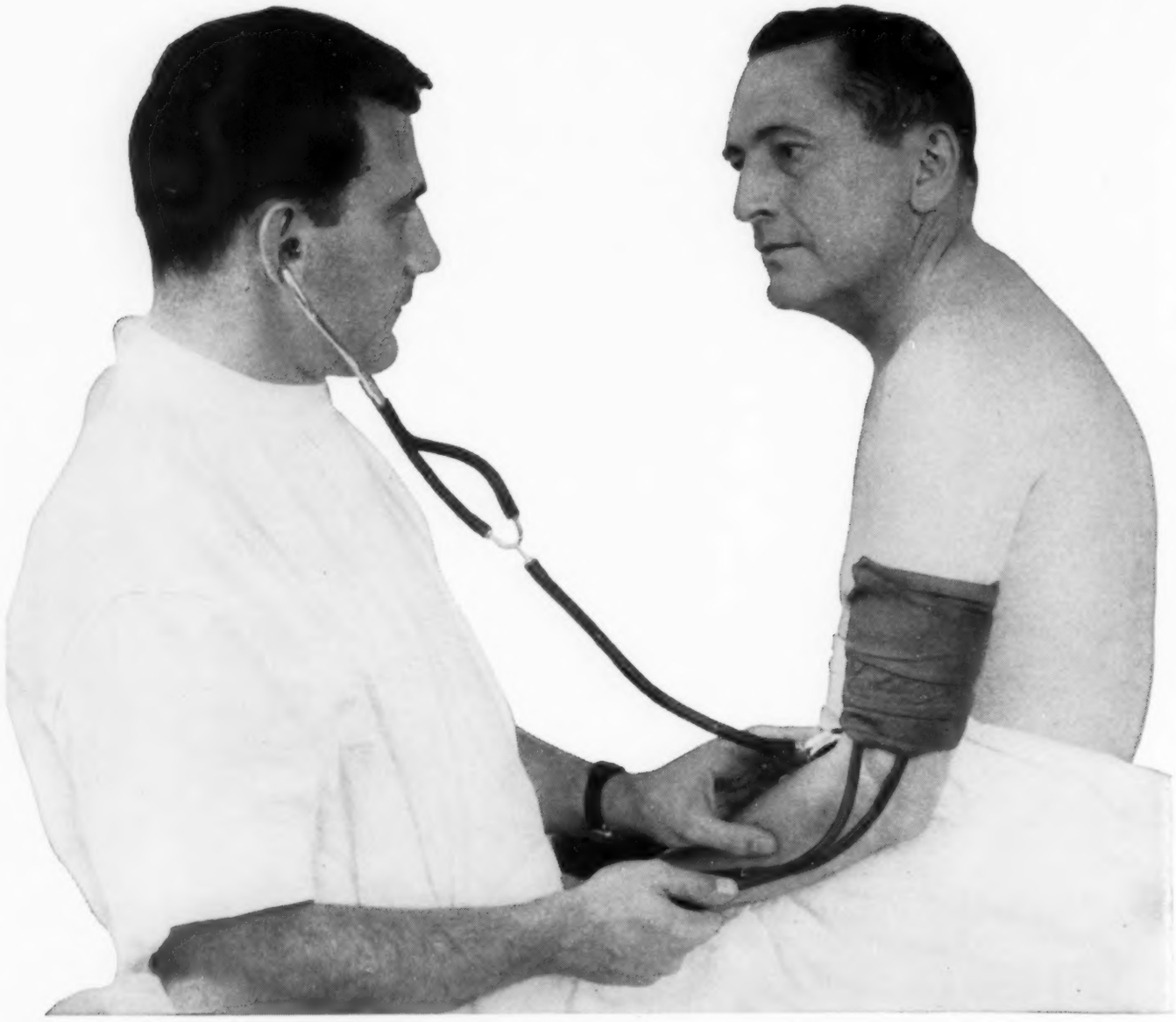

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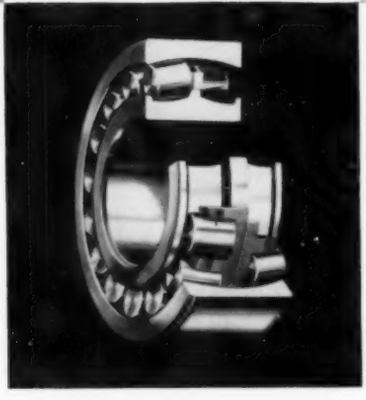

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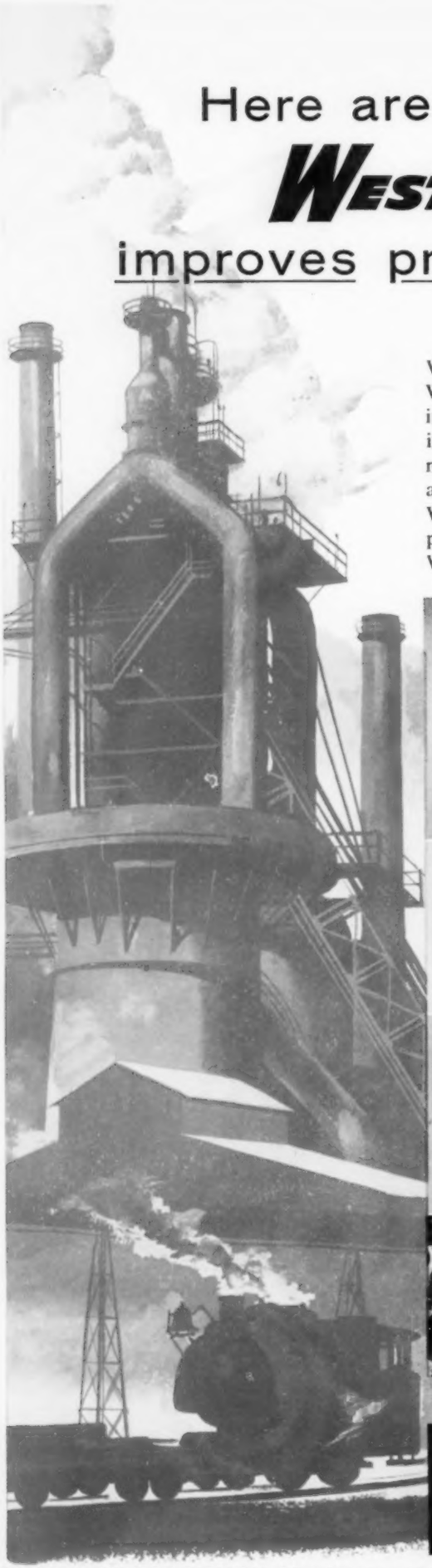
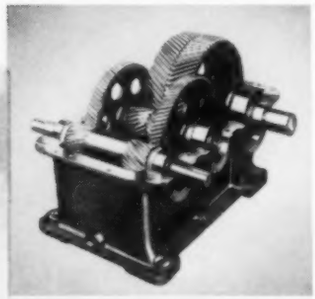
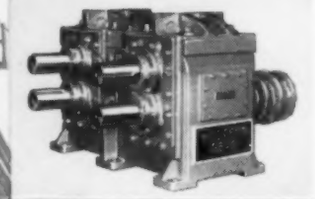


Working in close cooperation with the steel industry for 68 years, Western Gear has achieved a backlog of experience and know-how of inestimable value to the steel mill engineer. Take advantage of this intimate knowledge of America's basic industry. Ask for one of our steel mill application engineers to consult with you relative to the diverse and specialized gears and gear products necessary to the steel industry. We invite, without obligation on your part, inquiries concerning any power transmission or gear applications you are considering. Write: General Offices, Western Gear, P.O. Box 182, Lynwood, California.



Speed Reducers Wherever you find efficient steel production, you are apt to find the mill relying on Western Gear to provide its speed reducer needs. Capacities of these units range to 10,000 HP. As a result of years of successful service to the industry, Western Gear speed reducers are utilized on main mill drives and auxiliary drives in steel mill centers everywhere. Western Gear reducers are also used on cranes, for trolley, bridge and hoist drives as well as all types of conveyors.



Pinion Stands Western Gear has enjoyed the unique experience of supplying pinion stands to steel mills throughout the nation. Capacities range to 5000 HP. Conservative design with compact, rigidly constructed gear cases, precision cut gearing and carefully selected bearings are all a must in the production of a Western Gear mill pinion stand.

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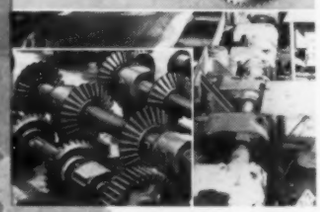

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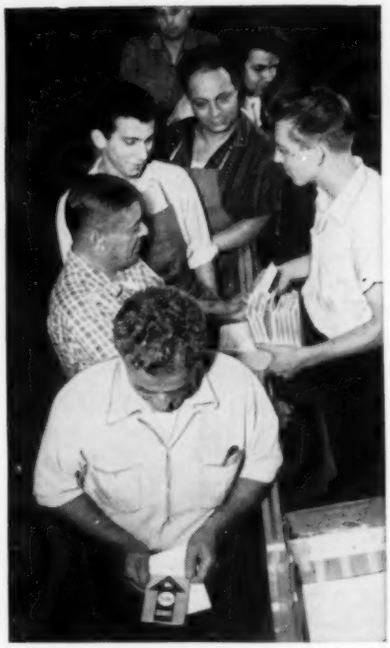
BOOK REVIEWS

(Continued from page 263)

as background material for anyone interested in the possible application of computers to their particular problems. Several photographs and line drawings are used to illustrate the text.

"Tinplate Handbook" (third revised edition), by W. E. Hoare, has been published recently by the Tin Research Institute, 492 West Sixth Avenue, Columbus 4, Ohio. The book contains 44 pages, 10 x 6 in., is bound in heavy paper, and is available free of charge on request to the Institute. This handbook contains nine sections, describing tinplate and its manufacture, world production, grades, qualities, packing and applications. There are 16 tables and several illustrations supporting the text; also a glossary of tinplate terms, listing equivalents in English, French, German, Spanish.

"Simplified Problems in Strength of Materials and Structural Design," by Ephraim Vertels, has been recently published by the Arco Publishing Co., 480 Lexington Avenue, New York 17, N. Y. The book contains 636 pages, 8 $^1/_2$ x 5 $^1/_2$ in., is cloth bound, and sells for $5. This is an all-problem reference book, divided into three parts under twenty-two section headings. Part I includes simple stresses; graphic statics; center of gravity; reactions of beams, girders, roof trusses, arches; shear and shear diagrams; bending moment and moment diagrams; influence lines; torsion. Part II covers elements of theory of bending; moment of inertia; design of steel beams; design of wooden beams; floor design; rivets and riveted connections; welding and welded connections. Part III has separate sections on the design of plate girders, columns, bearing plates, and roof trusses. There are a total of 735 problems solved in a step-by-step fashion.



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In factories, plants and offices across the nation, the line is busy. Through films, pamphlets, posters, exhibits and lectures, the life-line of cancer education is reaching more and more men and women in business and industry.

All of us are concerned with the major threat which cancer poses. Today, thousands of lives are being saved each year, but many more would be saved if people went to their doctors *in time*. This, and many other facts of life about cancer, are part of the education program which the American Cancer Society offers you in your plant or factory. For additional information, call the American Cancer Society office nearest you, or write to "Cancer" in care of your local Post Office.

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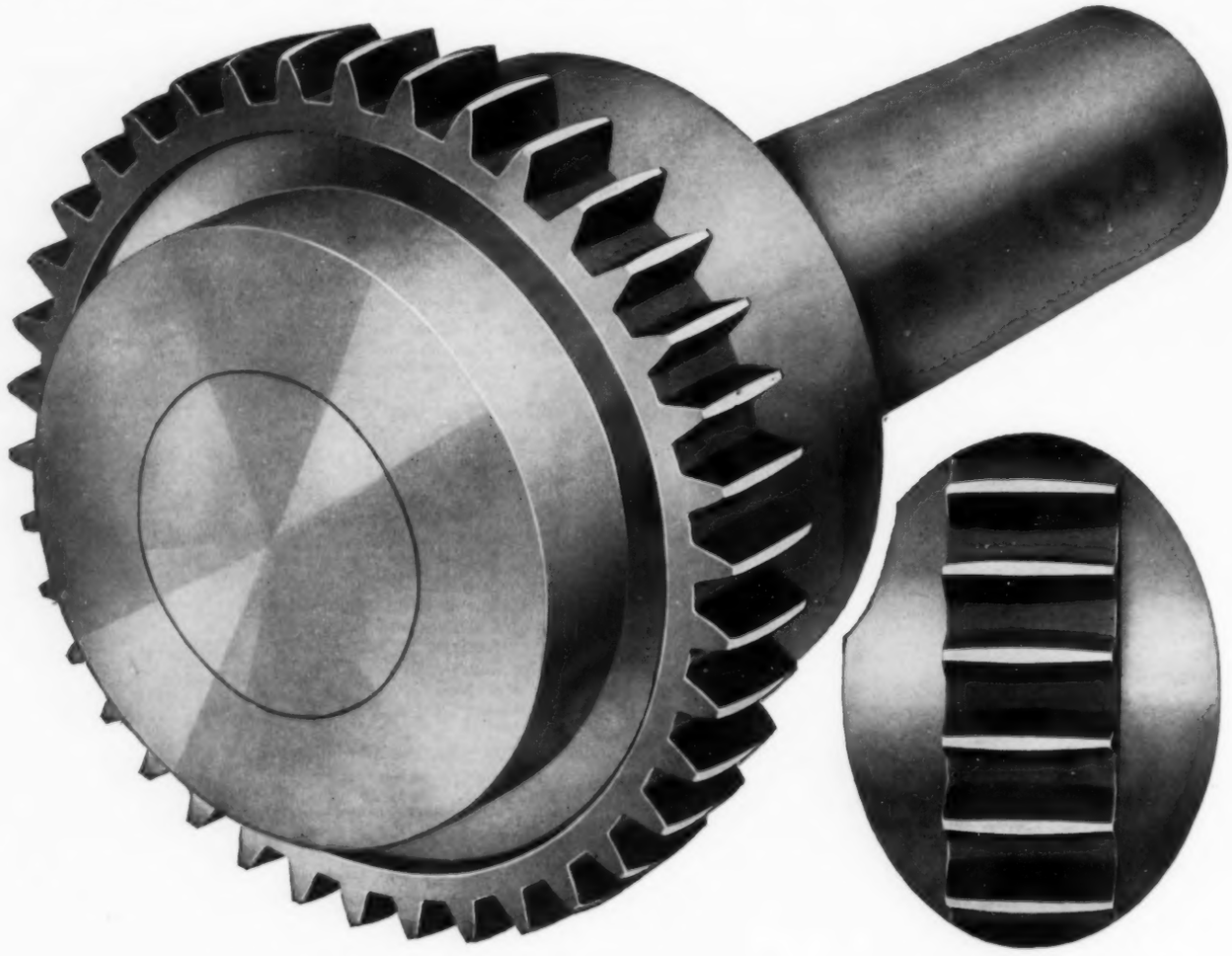

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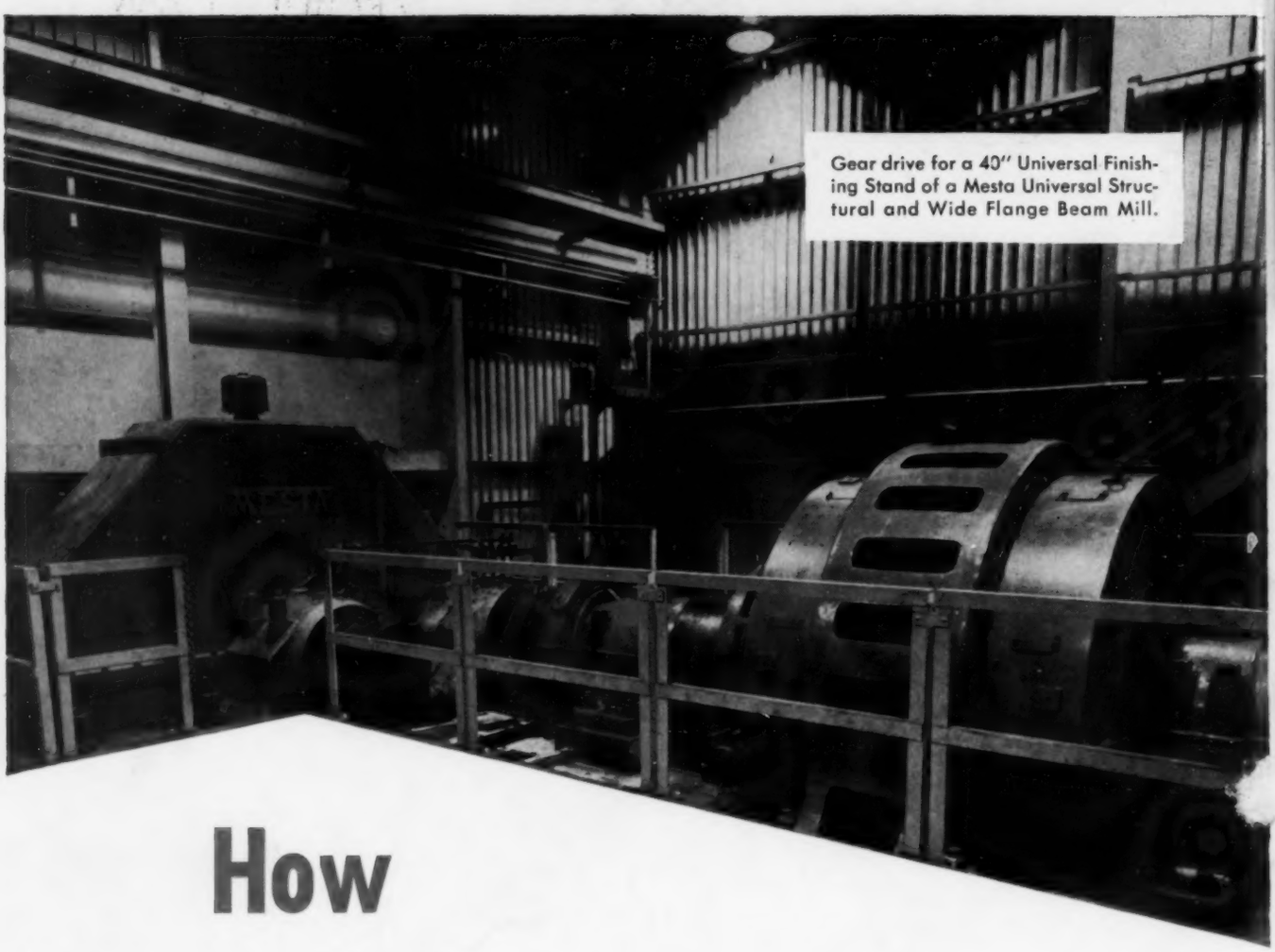

Gear drive for a 40" Universal Finishing Stand of a Mesta Universal Structural and Wide Flange Beam Mill.

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